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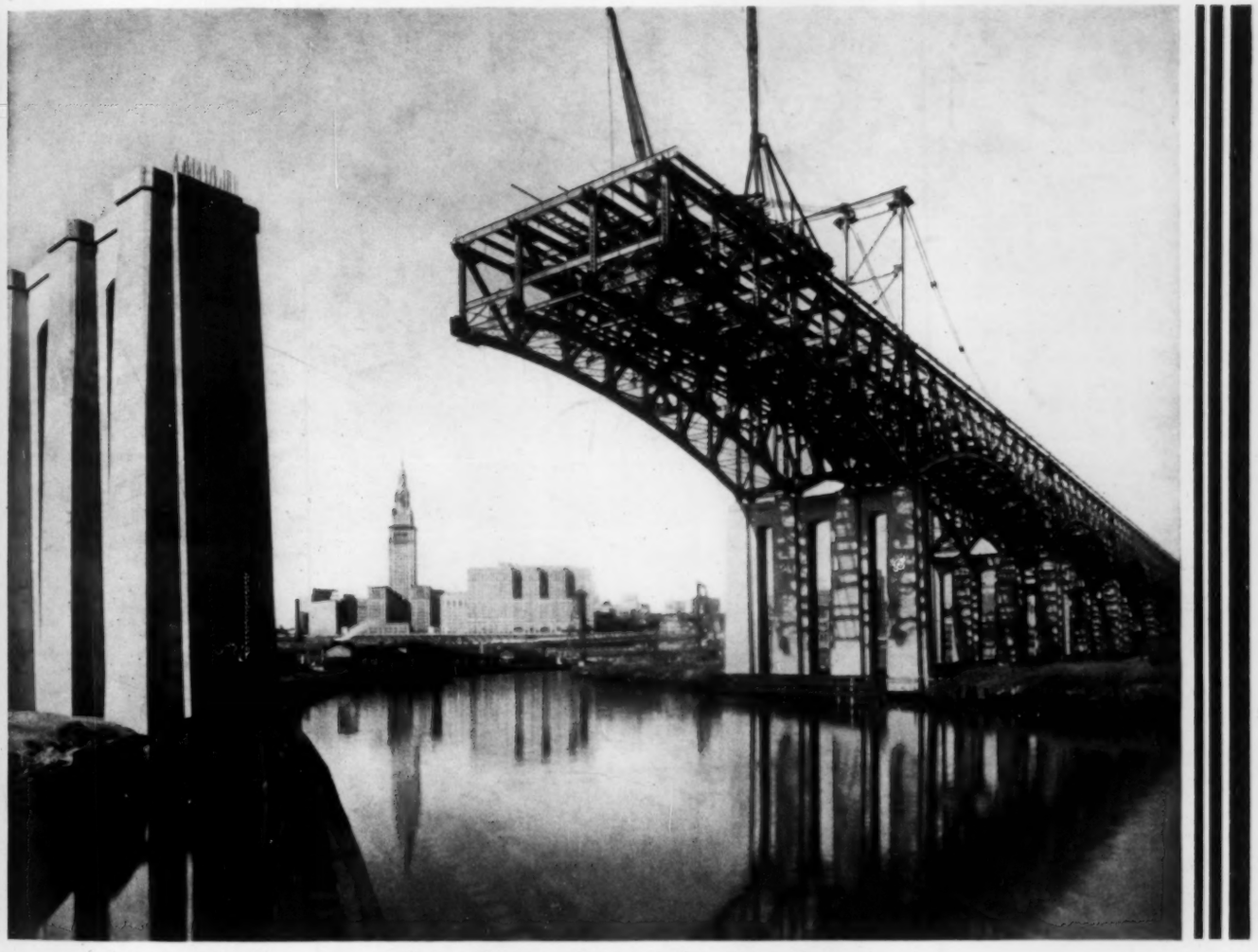
CIVIL ENGINEERING

Published by the American Society of Civil Engineers



LORAIN-CARNEGIE BRIDGE IN CLEVELAND, OHIO
To Be Opened for Traffic in November 1932

Volume 2 — Number 11

NOVEMBER 1932

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Among Our Writers

GEORGE T. SEABURY, elected Secretary of the American Society of Civil Engineers on December 1, 1924, is the fourteenth person to have executive charge of the Society's activities. His access to the Society's records, and more particularly to the summaries previously prepared by Charles Warren Hunt, Secretary for 28 years, make the article on the eighty years of the life of the Society, as authoritative as practicable with regard to dates, figures, and events.

HUBERT ENGELS in 1890 became Professor of Hydraulics at the Technical University in Dresden, Germany. Beginning in 1898 at Dresden he has spent a lifetime on hydraulic research with models. He resigned as professor in 1924, but has been active in recent years on the advisory council of the Walchensee Laboratory.

HANS KRAMER graduated from West Point in 1918. His varied experience as an engineer officer includes four years as Professor of Military Science and Tactics at the California Institute of Technology and two years as Assistant to the U.S. District Engineer in Philadelphia.

CLEMENT C. WILLIAMS served successively as head of the civil engineering departments at the Universities of Kansas and Illinois before going to the University of Iowa as Dean of the College of Engineering. His teaching career has been interspersed with consulting work. He is the author of several textbooks.

WILBUR J. WATSON is well known as a designer of bridges. Those designed by him include practically all types, for both railway and highway use. Among his recent projects is the airship factory and dock for the Goodyear Zeppelin Corporation, at Akron, Ohio, described in the November 1930 issue of CIVIL ENGINEERING.

A. H. FINLAY graduated in civil engineering from the University of British Columbia in 1924, and in 1925 was awarded a Research Graduate Assistantship in the Engineering Experiment Station, University of Illinois. Since receiving his M.S. there in 1927, he has been Assistant Professor of Civil Engineering at the University of British Columbia.

A. STREIFF, before he came to the United States in 1908, was assistant engineer on the Rotterdam Waterway and on the works for the relocation of the Meuse estuary in Holland. He has been connected in this country with the design and construction of many important dams, among them the Wissota Dam in Wisconsin and the Hamilton Dam in Texas.

JOHN R. MONAGHAN has had long experience in New York in responsible charge of subway work. Between 1918 and 1921 he was with the Turner Construction Company as auditor in charge of the accounting department, on the building of the Brooklyn Naval Supply Base.

JOHN J. FITZGERALD, JR., after graduation in 1924, from the Catholic University in Washington, D.C., took charge for the contractor of construction of the Columbus Circle Station on the new Eighth Avenue Subway in New York.

HOWARD F. PECKWORTH, who graduated from Princeton in 1926, has been associated with various contractors and consulting engineers on the construction of a number of sections of the new Eighth Avenue Subway in New York.

O. W. KOCHTITZKY, JR., graduated in 1932 from the Engineering School of the University of North Carolina, where he is now carrying on advanced study and research in sanitary and municipal engineering.

H. J. L. BRUFF is an English engineer who has been connected with the railroad industry for a number of years. Early in 1927 he took up the study of electric welding. He is the author of several papers on it as applied to railroad work, delivered before English societies.

VOLUME 2 NO. 11

November 1932

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This Issue Contains

AN UNUSUAL BRIDGE 1

EIGHTY YEARS OF GROWTH AND PROGRESS 665
George T. Seabury

LARGE-SCALE EXPERIMENTS IN RIVER HYDRAULICS 670
Hubert Engels
Hans Kramer

SMALL EARTH VIBRATIONS AFFECT FOUNDATIONS 675
Clement C. Williams

LORAIN-CARNEGIE BRIDGE IN CLEVELAND 680
Wilbur J. Watson

DECK PARTICIPATION IN CONCRETE ARCH BRIDGES 685
A. H. Finlay

SYSTEMATIC SEQUENCES IN ANNUAL STREAM FLOW 690
A. Streiff

DIFFICULT SUBWAY CONSTRUCTION IN SAND 693
John R. Monaghan
John J. Fitzgerald, Jr.
Howard F. Peckworth

A STUDY OF MOTOR TRANSPORT 698
O. W. Kochtitzky, Jr.

STRENGTHENING BRIDGES BY WELDING 701
H. J. L. Bruff

HINTS THAT HELP:
Rubbing Bed Grinds Test Cylinders and Cores 704
W. J. Harris

OUR READERS SAY 705

SOCIETY AFFAIRS 710

Inspiring Fall Meeting at Atlantic City; Honorary Members Elected; Secretary's Abstract of Board of Direction Meeting, October 3 and 4, 1932; Alonzo J. Hammond, Choice of Nominating Committee; Three New Honorary Members; Charles Warren Hunt—Minute Adopted by the Board of Direction, October 3, 1932; Official Nominees for Society Offices in 1933 Announced; John Ripley Freeman, 1855–1932; Death of Colonel Slattery Memorialized by the Board of Direction; Society Prizes for 1932; Additions to Executive Committees of Divisions; A Christmas Suggestion—For Ladies Only; Another Group of Memoirs Available; More Student Prize Winners; A Preview of PROCEEDINGS; News of Local Sections, Student Chapter News; American Engineering Council

ITEMS OF INTEREST 718

NEWS OF ENGINEERS 719

MEMBERSHIP—ADDITIONS AND CHANGES 720

MEN AVAILABLE 720

RECENT BOOKS 7

CURRENT PERIODICAL LITERATURE 8

INDEX TO ADVERTISERS, INDUSTRIAL AND ALPHABETICAL . . 10, 14

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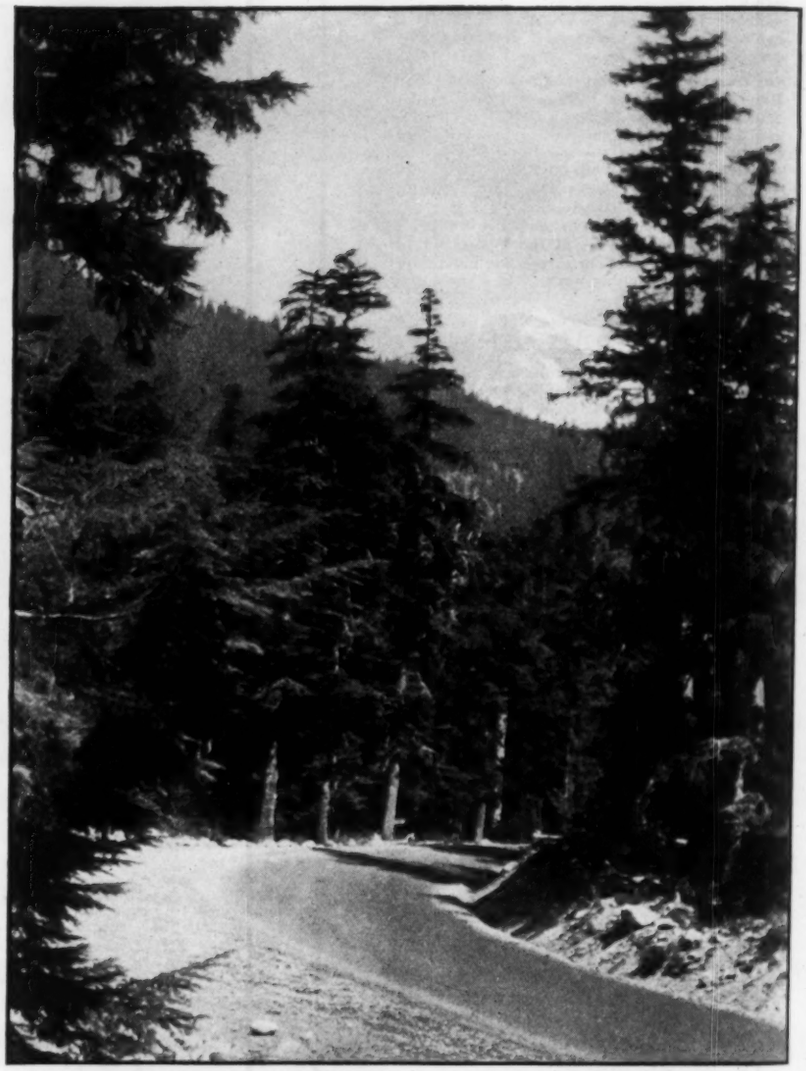

BIT-U-MULS

(BIT-YOU-MULLS)

The modern way to use Asphalt

One week before completion of the 1930 schedule, the project was buried under three feet of snow within 72 hours. The crew laid off a week then cleared the roadbed, thawed out the surfacing material and completed the work. Here is the contractor's car caught in the snow.

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CIVIL ENGINEERING

NOVEMBER 1932

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VOLUME 2

NUMBER 11

Eighty Years of Growth and Progress

Outstanding Events That Have Marked the Development of the American Society of Civil Engineers

By GEORGE T. SEABURY
SECRETARY AMERICAN SOCIETY OF CIVIL ENGINEERS

ENGINEERING SOCIETIES BUILDING, NEW YORK

IN the month of November 1932, the Society reaches the age of eighty years. It is fitting, therefore, to sketch briefly the early aspirations and struggles of the civil engineers on this continent to establish this organization, to give something of a picture of the Society as it has progressed, and to outline what it is doing at this anniversary.

Although the formation of a national society of civil engineers in the United States was first attempted at Baltimore in 1839, it was not until November 5, 1852, that a small group of civil engineers met in the office of Alfred W. Craven, then the eminent Chief Engineer of the Croton Aqueduct for the City of New York, and formed the "American Society of Civil Engineers and Architects." James Laurie was elected president of the Society. Little did he realize that he was destined to hold that office for fifteen years.

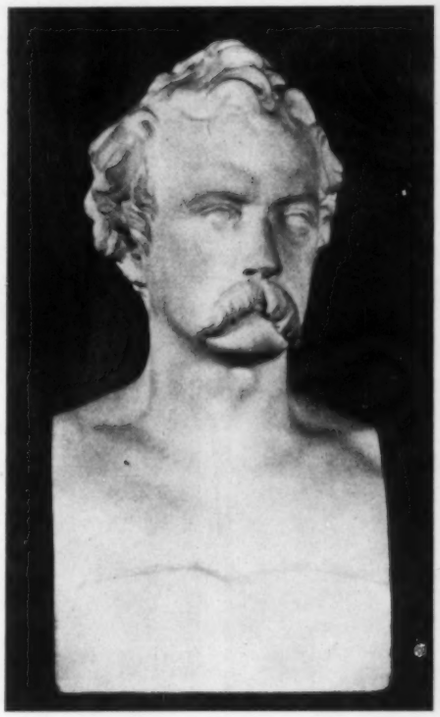
The objects of the new society were declared to be: "The professional improvement of its members, the encouragement of social intercourse among men of practical science, the advancement of engineering in its several branches, and of architecture, and the establishment of a central point of reference and union for its members." With very slight changes in phrasing, these objects form a part of the Constitution today.

Although the Society from its first beginnings took the name "American," and intended to include in its membership engineers from all over the country, activities of the first few years were confined to the City of New York. Indeed, a certain engineer residing in Boston, who was invited to become a member, declined the honor, saying that "members at a distance could hardly expect to attend the meetings with certainty."

Meetings were held until March 2, 1855, but not thereafter until October 2, 1867, when President Laurie called a meeting, at which nine members were present, to resuscitate and reorganize the Society. One of the first items of business was the reading and acceptance of the minutes of the previous meeting held 12 years before. It is to the lasting credit of this small group that interest in the Society was revived.

At the first annual meeting of the Society, on November 6, 1867, James P. Kirkwood was elected its second president. During the next year, the name of the Society was changed to "American Society of Civil Engineers," eliminating the words "and Architects"; the library was started; and William J. McAlpine, who later made generous contributions to the library, became the Society's third president.

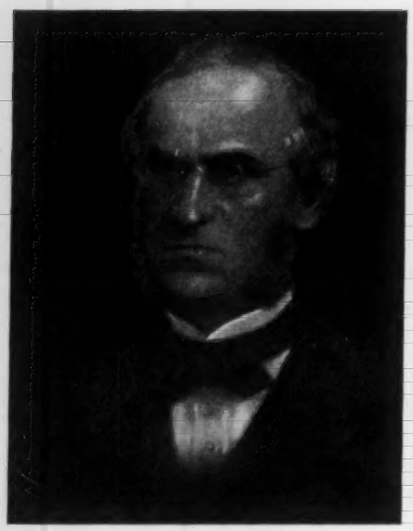
In 1869, at the first Annual Convention, there were 55 present. During this year Alfred W. Craven, in whose office the Society had been instituted 15 years before, was elected to the presidency. He held this office for the succeeding two years.



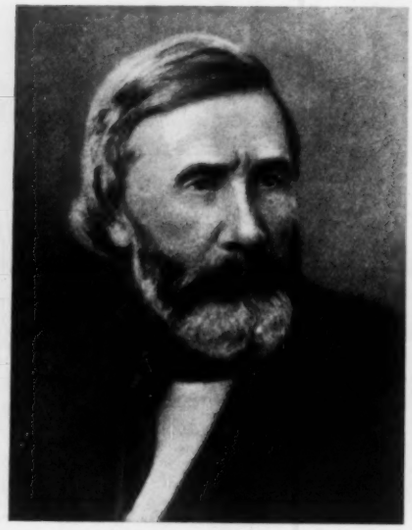
BUST OF ALFRED W. CRAVEN
In Whose Office the Society Was Founded

A number of forward-looking steps were taken during Mr. Craven's administration, which later, in 1872, resulted in the further advance of the Society as national in scope. The first of these was the holding of the Fourth Annual Convention, in Chicago, the beginning of a practice since continued—that of periodically convening the Society members at points distributed throughout the country. Indeed, several meetings have been held outside the United States.

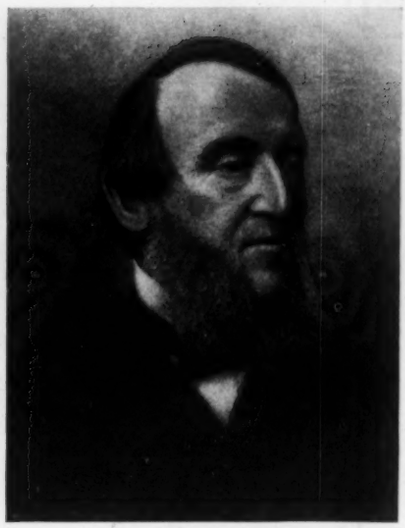
It was during 1872, also, that Volume 1 of TRANSACTIONS appeared. In that year the Norman Medal was established by the late George H. Norman, M. Am. Soc. C.E., for the best paper "judged worthy of special commendation for its merit as a contribution to engineering science," written by a member and published in PROCEEDINGS, then bound in TRANSACTIONS. Mr. Norman himself prepared the design for the die, which was deposited with the Superintendent of the Mint



James Laurie



James P. Kirkwood



William J. McAlpine

FIRST THREE PRESIDENTS OF THE SOCIETY

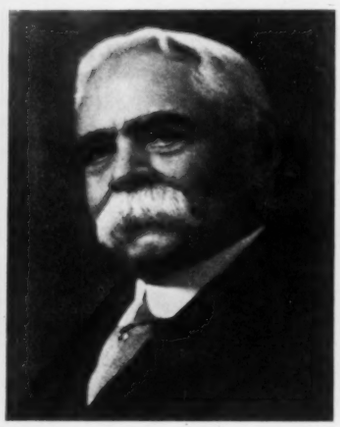
in Philadelphia, in whose custody it has remained without change up to the present time. Horatio Allen was elected president to succeed Mr. Craven, and the Secretary for the first time was made a salaried officer.

In 1873 the Convention was held in Louisville, Ky., and, according to the annual report of that year, was attended by the largest group of civil engineers ever assembled on this continent—70 Members and Fellows. Records in the Society files indicate that in this year the total membership was 414, of which 70 per cent was non-resident. Today 83 per cent of the membership of the Society is non-resident, that is, located more than 50 miles distant from the post-office of the City of New York.

PERMANENT HEADQUARTERS FOUND NECESSARY

From the start, permanent quarters were deemed essential. The rooms occupied since 1867 in the Chamber of Commerce Building became inadequate and in 1875 new and larger quarters were established at 23d Street and Broadway overlooking Madison Square. On May 1, 1877, an old residence was rented at 104 East 20th Street, and agitation for a building fund was begun, which resulted in the purchase of a house at 127 East 23d Street. After alteration, this was occupied in April 1881.

In 1896, after considerable study, a site was acquired at 220 West 57th Street, and a building specially planned for the Society's needs was opened in November 1897. In 1904 the purchase of an adjoining lot made possible the enlargement of the building, increasing its capacity by 50 per cent. Through the generosity of Andrew Carnegie, the Engineering Societies Building on West 39th Street was erected in 1906. The Society had been invited to share in it but was reluctant to leave its own home; hence it was not until 1916 that, by a majority vote of the Corporate Membership, the decision was made to occupy the headquarters of the other engineering societies. The building and land on West 57th Street still remain the property of the Society and return a substantial income.



JOHN BOGART
Secretary, 1877–1891

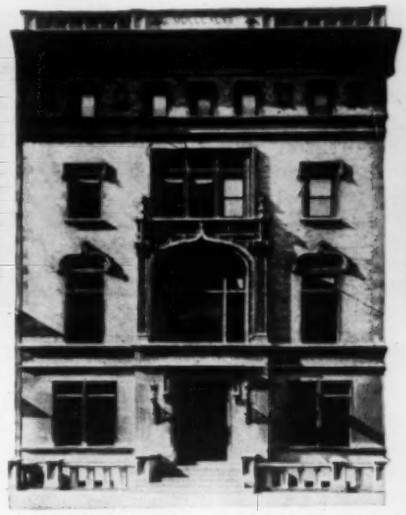
CHARLES WARREN HUNT
Secretary, 1895–1920

PUBLICATIONS DEEMED IMPORTANT BY SOCIETY FOUNDERS

Throughout the whole history of the Society, its outstanding contribution to the profession has been in the form of prepared technical papers and reports, presented and discussed at meetings. Since 1872, these have been published continuously in the volumes of TRANSACTIONS. The monthly issues of PROCEEDINGS, at first bound with the monthly TRANSACTIONS, have been brought out separately since 1896. Monthly, since October 1930, the Society has published CIVIL ENGINEERING, which carries the more animated and graphic articles submitted for publication and brings the current news of the profession and of Society activities to all members and non-member readers.

As the membership of the Society is scattered throughout the world, it has long since been out of the question for any considerable percentage of the membership to attend any one meeting. To render service, therefore, the publications have been systematically developed as a complete presentation of Society activities, technical and non-technical. At the expense of both space and money, approved papers, reports, and appendixes have been printed in detail, in order that the fundamental data as well as the process of reasoning and the conclusions may be equally available to every member, situated wherever he may be. Last year 2,200,000 words of manuscript were set into type and, supplemented by illustrations, diagrams, and captions,

LIBRARY IN EAST 23D STREET HOUSE
1881–1897



SOCIETY HOUSE AT WEST 57TH STREET
1897–1917

READING ROOM AT WEST 39TH STREET
As It Appears Today

were published by the Society. These represented, when issued in editions sufficient to supply every member, upward of 80,000,000 pages of printed matter.

A deep interest of the founders lay in the library, which, with a museum, they aimed to establish in permanent rooms at the headquarters of the Society. For many years the carefully compiled collection of books was widely consulted at Headquarters. Since 1916, it has been merged with the Engineering Societies Library, located under the same roof as the Society offices, and constituting probably the finest technical library on this continent.

Membership has always been guarded by strict requirements for entrance, and the tendency has been to make these higher. Since 1926 there has been a net addition of 1,700 Juniors, 90 per cent of whom are recent graduates from the engineering schools of this country. Today the Junior grade in the Society comprises approximately 19 per cent of the total membership. In June 1931, this total passed the 15,000 mark and reached a peak of 15,362 in June 1932.

COMMITTEE ON DEVELOPMENT

A milestone in the more recent history of the Society is the work of the Committee on Development. In June 1918, the Board of Direction, when appointing this committee, resolved that: "A broad survey of the functions and purposes of the American Society of Civil Engineers is needed in order that an intelligent and effective readjustment may be accomplished so that the Society may take its proper place in the large sphere of influence and usefulness now opening to the profession." The studies made by the committee were grouped under the heads of: Technical Activities; Internal Relations and Local Associations; Relations with Other National Societies and Related Organizations; and Relation to Public Affairs.

Replies to a questionnaire sent to the members in 1920 indicated that the Society was ready to become "an active national force in economic, industrial and civic affairs" and to cooperate actively with other engineering societies and allied technical associations in promoting the welfare of the engineering profession. The report of the committee and the resulting discussion stimulated and broadened all the activities of the Society. As a result of its work, the Society in 1921 adopted a new and revised Constitution, under which have since been developed many of the committee's specific recommendations.

In 1925, the Committee on Aims and Activities made a similar study, reporting somewhat similar recommendations for the improvement of the Society. Again in 1930, the thought of participating vitally in the professional life of Society members in ways other than technical, found expression in the adoption of the Functional Expansion Program, in accordance with which the By-Laws were amended and still further activities initiated.

Under the Functional Expansion Program a radical departure in administration was made. Through the agency of committees advisory to the Board of Direction, specific responsibility for the functioning of each committee was assigned to Corporate Members located throughout the country but resident sufficiently near together to permit of frequent meetings. Thus was brought into active Society management a new group of 40 men who had demonstrated their interest not only in the Society but also in the specific activity to the study of which they were assigned.

Under the Functional Expansion Program, supplementing the thoughts in the report of the Committee on Development, the Board's Advisory Committees were divided into three departments—a Technical Department, consisting of the Society's Research Committees and the several Technical Divisions, with their subcommittees; an Administrative Department, with committees studying the problems of Student Chapters, Juniors, and Local Sections, and advising the Board regarding them; and a Professional Department, with committees charged with the study of engineering education, education of the public, legislation, registration of engineers, fees, and salaries. Further assistance to the profession along lines other than technical resulted when the Society in 1929 voted to become one of the member bodies of the American Engineering Council. By this action the Council was enabled more effectively to function as a joint agency "to further the public welfare wherever technical knowledge and engineering experience are involved, and to consider and act upon matters of common concern to the engineering and allied technical professions."

Researches of one form or another have engaged the attention of the Society from its inception. At the very first professional discussion, on January 5, 1853, Presi-

SOURCES OF INFORMATION

HISTORICAL SKETCH OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS, *by Charles Warren Hunt. 1897.*

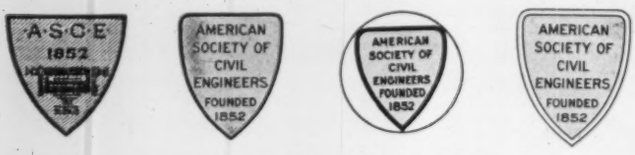
THE FIRST FIFTY YEARS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS: 1852–1902, *by Charles Warren Hunt. 1902.*

THE ACTIVITIES OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS DURING THE PAST TWENTY-FIVE YEARS, *by Charles Warren Hunt. 1917.*

Minutes of the Board of Direction, PROCEEDINGS, *Society files, and reports.*

dent James Laurie reported on "The Relief of Broadway," suggesting the erection of railway tracks above the level of the street.

The Society's first research committee was appointed in 1872 to impress upon Congress the necessity of inaugurating the scientific examination of iron and steel. For more than ten years a committee, appointed in 1881, studied diligently, and was very largely influential in attaining the adoption of, standard time,



THE EVOLUTION OF THE BADGE

Left: Blue for All Grades, 1884–1894. Left Center: Blue for Corporate Members, 1894 to Date; Maroon for Affiliates, 1894–1931; Blue for Affiliates, 1931 to Date. Right Center: Blue on White for Juniors, and Maroon on White for Students, 1924–1926. Right: Blue with White Border for Juniors, and Maroon with White Border for Students, 1926 to Date.

now in use both in this country and abroad. The same committee advocated the use of the 24-hour system. The Society used this system from 1888 to 1899 but at the meeting of the Board of Direction held October 3, 1899, its use was discontinued. This meeting of the Board is recorded as having been called to order at "20.30 o'clock," but it was adjourned at "11.15 p.m."

Among the reports that remain as classics in engineering research is one which resulted in the adoption by railroads of the Standard A.S.C.E. rail section; one on the Valuation of Public Utilities; and another on Uniform Tests of Cement—to mention but a few.

More recently Society committees have assisted the Congress of the United States in its study of the Mississippi River flood control problem; in the planning of Washington, D.C.; and, this year, in making available Federal credit facilities to solvent states, counties, and municipalities to permit them to carry forward their normal programs of worthy and productive public works.

Special Society committees are now studying Concrete and Reinforced Concrete Arches, Steel Columns, Irrigation Hydraulics, Earths and Foundations, Stresses in Railroad Tracks, Cement, Dams, and Meteorological Data. Under the administration of the technical Divisions, 36 other committees are studying a variety of important technical matters.

REGISTRATION OF ENGINEERS RECEIVES SOCIETY'S ENDORSEMENT

Registration of engineers, first called "licensing," was brought before the Board of Direction in the year 1910. The following year a draft of a model law was prepared, which was recommended by the Board to such states as wished to enact the law. Both the Board and the Annual Meeting of the Society went on record as not in favor of such legislation.

In 1915, by a letter ballot, the Corporate Members of the Society rescinded this action, but the Board of Direction did not give its approval to the principle of the registration of engineers until July 1931. In the intervening years, several revisions of a recommended uniform registration law were prepared, studied, approved, and revised, with the help of representatives from many interested engineering societies. The latest revision of this law was adopted and endorsed by the Board of Direction in July 1932.

EMPLOYMENT SERVICE

As early as 1872 the records show that the Society stood ready to aid those seeking engagement and those requiring engineering services. A circular issued in that year stated, "Members thus commanding the Secretary are requested to state explicitly what is required, and he will endeavor to execute their commissions with reasonable promptitude, without charge."

In 1918 a clearing house of the employment activities of the four Founders Societies was created in the Engineering Societies Employment Bureau. Since 1923 this service has been carried forward under the direction of the secretaries of these societies. Offices are maintained in New York, Chicago, and San Francisco.

CODE OF ETHICS

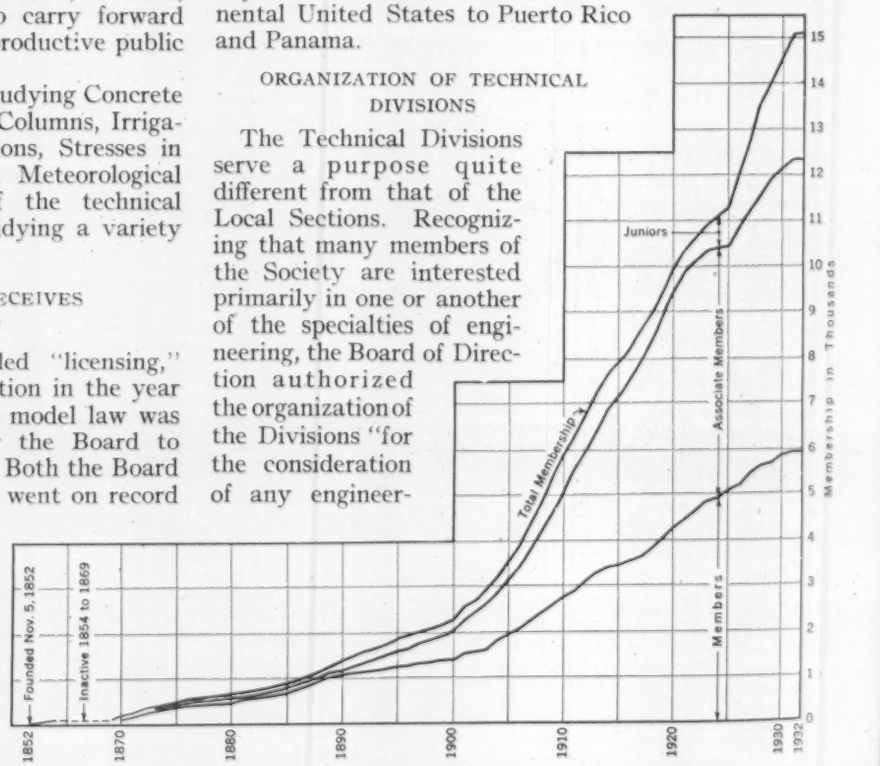
The development of a Code of Ethics engaged the attention of the Society for a number of years. First suggested as early as 1893, and discussed pro and con for some time, the present code was adopted by letter ballot of the Corporate Membership in 1914. In terms of that code, the Board of Direction has determined many cases of controversy and charges of unethical conduct, action resulting in more than one instance in the expulsion of members, or in enforced resignation.

As early as 1872, groups of members, now known as Local Sections, were considered. Ten years later the matter came up for vote but was defeated, perhaps because the plan contemplated the formation of the groups not only on the basis of location but also for the study of special branches of engineering—a purpose now fulfilled by the Technical Divisions.

The formation of local "Associations of Members" was approved by the Annual Convention in 1905, and there are now 56 "Local Sections," extending even beyond the confines of the continental United States to Puerto Rico and Panama.

ORGANIZATION OF TECHNICAL DIVISIONS

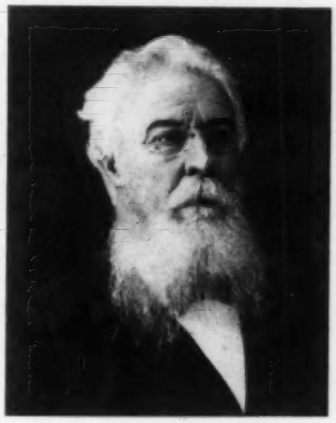
The Technical Divisions serve a purpose quite different from that of the Local Sections. Recognizing that many members of the Society are interested primarily in one or another of the specialties of engineering, the Board of Direction authorized the organization of the Divisions "for the consideration of any engineer-



GROWTH OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS

ing scientific, or professional subject." Since the formation of the Sanitary Engineering Division, in 1922, ten such groupings, in all, have been formed, the latest, the Engineering-Economics and Finance Division, showing by its name the interest that members are taking in such questions.

The work of the Divisions appears chiefly in the technical papers presented at their sessions during the quarterly meetings of the Society, and in the work of their committees, the findings of which are published in the series of Manuals and in PROCEEDINGS.



GEORGE H. NORMAN
Who in 1872 Instituted and Endowed the Norman Medal

A proposal was made in 1917 for the establishment of "student branches," but the matter was held in abeyance on account of the World War. After the general report of the Committee on Development, submitted in 1919, which favored this action, the Board of Direction in 1920 authorized the establishment of Student Chapters, and the first Chapter, that at Stanford University, was approved. By the end of the year there were already eight Chapters, with a membership of about 300. The present number of Chapters is 102, and the total membership, as of March 1932, is 5,269. This figure is not included in totals of Society membership as the students do not possess the minimum requirements of membership.

PARTICIPATION IN THE WORLD WAR

No history of the Society would be acceptable without chronicling the important participation by its membership in the World War. In 1918 the membership totaled approximately 8,000, of whom 1,763 went into uniform, almost universally with officers' commissions, and of whom 27 died in service, most of them in battle. No record has been compiled of the number of other members who contributed as advisors and as assistants in the engineering departments of the uniformed services, but such records as are available indicate an almost wholesale mobilization of the membership. It was said to be an "engineers' war."

In both 1917 and 1918 the Annual Convention was not held, and the dues of all members in military service were suspended. Free use of the Society's 57th Street House was given to the Food Administration of the United States. Partly because of the Government's desire to conserve paper, partly because of lack of funds, and especially because of the absence of author-members in service, the 1919 volume of TRANSACTIONS was omitted.

LOYALTY TO THE SOCIETY

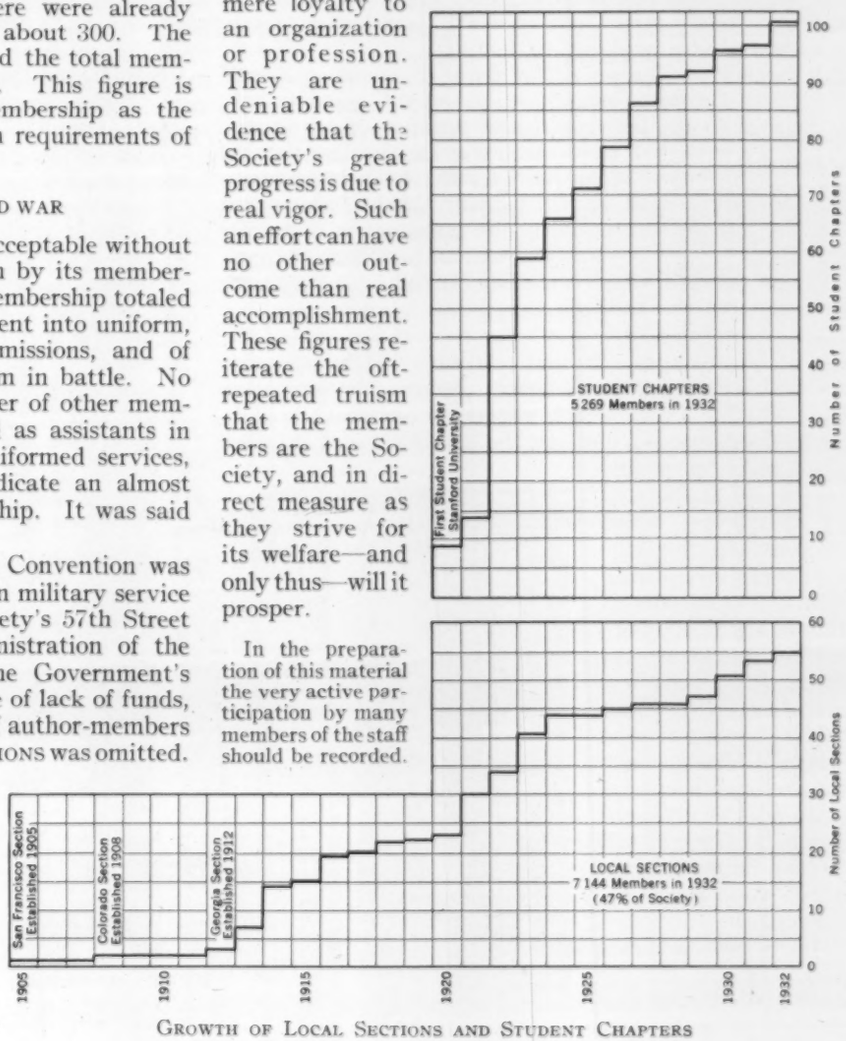
There are many evidences of the loyalty and enthusiasm of members and their readiness to serve the Society. A study made as for the year 1931 shows that some 800 authors contributed to the Society's publications, their contributions having been passed on by nearly 200 experts. These papers provoked 472 discussions. In addition, 170 Society members served on Research Committees and 380 as members of Technical Division committees. A summation gives the impressive total of over 2,000 members working on the technical phases of the Society's activities.

On local membership committees, 230 members assisted the Board of Direction in studying the applications for admission and transfer; 300 more labored on meeting committees; another 100 acted as faculty sponsors to Student Chapters; 80 are on the Board of Direction and its advisory committees; 50 represented the Society in joint activities with other organizations; and another 40 participated in Local Section Conferences. Thus, over 800 worked on the national administration of the Society.

Allowing each Local Section a president and secretary would account for 106 members, not to mention the other officers and committees of the Sections. Student Chapter Contact Members numbered 90; local contact members for the Committee on Salaries totaled 100; another 100 served on functional expansion committees; 140 also assisted the Committee on Meteorological Data and 75 more worked on unemployment committees—or a total of at least 600 who were engaged locally in the Society's activities. It is safe to say that at least 3,450 members gave of their time and energy in that single year to the Society in the furtherance of one or another of its many activities.

These data, properly interpreted, mean more than a mere loyalty to an organization or profession. They are undeniable evidence that the Society's great progress is due to real vigor. Such an effort can have no other outcome than real accomplishment. These figures reiterate the oft-repeated truism that the members are the Society, and in direct measure as they strive for its welfare—and only thus—will it prosper.

In the preparation of this material the very active participation by many members of the staff should be recorded.



GROWTH OF LOCAL SECTIONS AND STUDENT CHAPTERS

Large-Scale Experiments in River Hydraulics

Conducted by the Research Institute for Hydraulic Engineering and Water Power, Germany

By HUBERT ENGELS
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TECHNICAL UNIVERSITY OF DRESDEN, GERMANY

Assisted by HANS KRAMER
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IN the summer of 1931 a series of large-scale model experiments was conducted at the Walchensee laboratory under the direction of Dr. Engels, with the collaboration of Lieutenant Kramer, then holder of the Freeman Traveling Scholarship for study abroad. The original idea was that an English translation of Dr. Engels' report on these experiments should be prepared by Lieutenant Kramer for publication in America. His translation, here presented in shortened form, was prepared contemporaneously with Dr. Engels' report, printed in "Wasserkraft und Wasserwirtschaft," in the issues for February 1 and 15, 1932. Of unusual interest to engineers are the valuable findings of these experimenters as to the travel of bed load, or "geschiebe," in a sinuous river channel, and the effect of various levee locations on the movable bed.

IN 1899 and again in 1923 a series of small-scale experiments in fluvial hydraulics was conducted in the hydraulic laboratory of the Technical University at Dresden, Germany. To amplify these earlier experiments as well as to eliminate sources of justifiable criticism, a series of large-scale experiments was undertaken under the auspices of the Research Institute for Hydraulic Engineering and Water Power, near Walchensee, Germany, in the summer of 1931.

The 1931 experiments dealt with two main problems. The first of these concerned the travel of the sedimentary material transported along the bed of a sinuous river channel by running water. Throughout this discussion the concise and widely used German word *geschiebe* will be employed to denote this material. The second of these problems concerned the effect of various levee locations on the movable bed.

As regards the first-mentioned problem, these experiments showed that *geschiebe* travels across the channel from the lower end of one convex bank to the next downstream convex bank on the opposite shore. This result was in full agreement with the conclusions of earlier experiments. As regards the second problem, the conclusions reached were: (1) that, for all levee locations investigated, the thalweg irregularities are greatest at high water, with little tendency toward leveling of the bed at lower stages; (2) that relatively widely separated straight levees produce a better channel for navigation than winding levees, which materially contract the high-water flood channel, but that the best channel is obtained when widely separated levees are augmented by spur levees, which concentrate the current over the crossings; and (3) that contraction of the flood channel by narrowing the distance between levees does not result in the lowering of flood stages. The successful and significant results of these experiments are attributed to the large scale on which they were carried out.

Previous research had indicated the necessity for further observations and measurements of natural streams and concurrent model experiments for the clarification of disputed questions concerning the nature of *geschiebe* travel in river bends and the effect of rising and falling stages on bed configuration.

The first experiments in this field were conducted by Dr. Engels in 1899 in the original Dresden Hydraulic Laboratory on a model that reproduced actual bends of the Elbe River, and were described by him in *Zeitschrift für Bauwesen*, 1900. The scale was approximately 1:400. The trapezodial cross section, with an initially horizontal bed, was 5 cm. deep. The length of the model was about 12 m. and its average width 42 cm. Experiments were conducted with a flow of 5.88 liters per sec. (about 0.21 sec-ft.). These experiments showed that the *geschiebe* travels from the lower end of a convex bank to the next downstream convex bank on the opposite side of the river, as shown in Fig. 1.

The second of the above-mentioned questions, the effect of rising and falling stages on bed configuration, was investigated by Dr. Engels in 1923 in the present Dresden Hydraulic Laboratory and the results reported in *Der Bauingenieur*, 1924. Reference is also made to *Hydraulic Laboratory Practice*, 1929, page 93, edited by the late John R. Freeman, Hon. M. Am. Soc. C.E. Again the curvature of the Elbe was reproduced on a model 25 m. long, and results showed that the irregularities of the bed along the thalweg increased with rising stages and decreased with falling stages.

Even though the experiments just described evidenced the known characteristics of water courses flowing between sinuous but fixed banks, for a number of reasons they cannot be considered as conclusive, especially since they were not acceptable to all members of the profession. In the first place, exception was taken to the very strong distortion of cross section in the model channel 40 cm. wide and 5 cm. deep, used to represent the natural channel. Moreover, in the second set of experiments the relation of the low-

GENERAL VIEW OF EXPERIMENTAL FLUME, WALCHENSEE, GERMANY

water to the high-water discharge of approximately 1:2.5 did not give similarity to nature, while in the first set of experiments no variation of discharge whatever was provided for.

The model bed of unigranular sand also constituted a deviation from nature. These high- and low-water experiments were further deficient in being limited to bank-full flow without overtopping. Furthermore, model experiments for the clarification of questions concerning bed configuration require as large a scale as possible, relatively large quantities of water, and a bed material more closely similar to nature. The necessity for changing from the small-scale model experiment to one of large scale becomes especially urgent for the extraordinarily important investigation of the effect of levees on a river bed.

THE EXPERIMENTAL PLANT USED

A general description of the layout and operation of the "Great German Hydraulic Laboratory" near Walchensee, by Hunter Rouse, appeared in the May 1931 number of CIVIL ENGINEERING. This article also announced the commencement of the experiments that are here described.

FIG. 1. TRAVEL OF "GESCHIEBE" IN A LARGE-SCALE MODEL
Actual Bends of the Elbe River Reproduced

The outdoor river model for these experiments was built into an open flume having a usable length of 100 m. and a bottom width of 10 m. The side walls of the flume were earth embankments on a slope of 1:1. Floor and sides were waterproofed with an asphalt coating. A general view of the experimental flume is shown in the accompanying photograph, and its plan is given in Fig. 2.

PLAN AND SCALE OF MODEL

In plan, the model built into the river flume near Walchensee was geometrically similar to the models previously investigated in the Dresden Hydraulic Laboratory, but the horizontal scale was approximately 1:55. The available flume width and the given conditions of curvature led to the adoption of a width for the model river of 250 cm. at top of bank. The model cross section, again, was trapezoidal.

Preliminary tests were conducted, and a suitable model *geschiebe* developed, consisting of sifted Isar Creek sand. This remained motionless at a slope of 0.001, with a depth of flow of 5 cm., but gradually commenced to move with increase in depth. Its composition is shown in Fig. 3. The channel bed and flood plain of the model river were given a slope of 0.001. The bed of Isar Creek sand was placed to a uniform thickness of 20 cm.

The 1:1 bank slopes were fixed by a thin coating of concrete, and the levee slopes were similarly treated.

The resulting model cross section, with its ratio of low-water depth to width of 1:50, was considerably less distorted than in the 1899 and 1923 experiments, in which this ratio was 1:8. The results of the 1931 experiments may be transferred to natural streams with greater justification, but direct comparison of results with those of the older experiments is impaired.

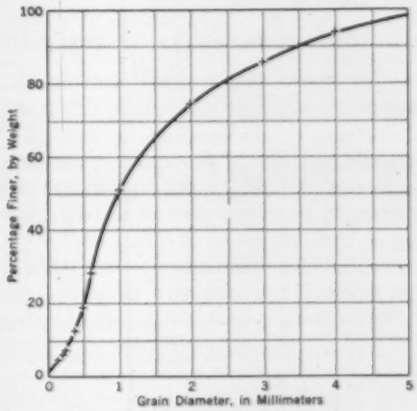

FIG. 3. SIEVE ANALYSIS OF ISAR CREEK SAND
Used as "Geschiebe" in the Model

CONDUCTING THE EXPERIMENTS

The experiments were conducted in three series, one for each of three different levee systems, each with the same main channel. In each series runs were conducted at low water, mean water (used in this discussion to indicate bank-full stage), and high water. For all three series, the discharges and durations of flow at low water were equal, as were also those at mean water and those at high water. The low-water depth was established at 5 cm. above the initially horizontal cross section of the bed; the mean-water depth amounted to 14 cm. at bank-full stage; and the high-water depth over the flood plain was 8, 10, and 12 cm., depending on the system of leveeing. The mean velocity at low water was approximately 0.14 m. per sec., and that of mean water was approximately 0.5 m. per sec. Turbulent flow prevailed during all runs. For all systems and at all stages, the surface slope of the water was maintained constant at

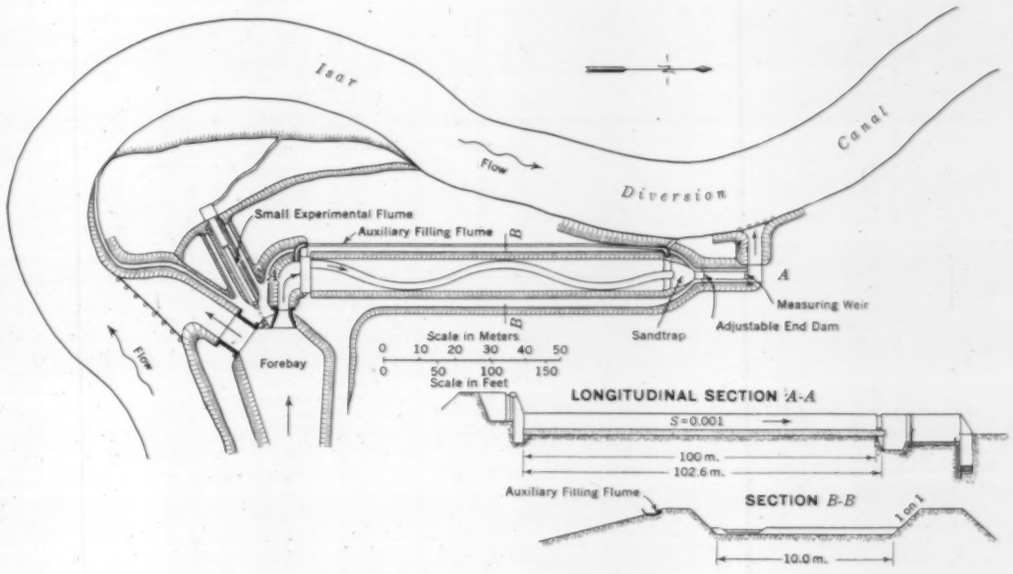

FIG. 2. GENERAL LAYOUT OF THE EXPERIMENTAL FLUME
Research Institute for Hydraulic Engineering and Water Power, Near Walchensee, Germany

0.001. In every test, equalization of the quantity of *geschiebe* introduced and that carried off was sought. The results of the tests were thus made comparable one with another.

THE THREE SERIES OF THE MAIN EXPERIMENTS

The main experiments embraced the following three series:

Series 1. Levees were straight and parallel and approximately 11 m. apart, as shown in Fig. 4.

Series 2. The same main levees were used as for Series 1, but spur levees were added in the flood plain, as in Fig. 5.

Series 3. Winding levees were built 4.5 m. apart, paralleling the bends of the river, as shown in Fig. 6.

Within each series the following runs were conducted:

After the model was filled a mean-water flow for 50 hours was maintained, followed by determination of flow line, draining of model, and taking of cross sections and photographs.

After refilling the model to mean-water stage, a 6-hour flow with rising stage from mean water to high water was maintained, followed by 24 hours of high water. Then the flow line was determined, the model was drained, and cross sections and photographs were taken.

After refilling the model to the high-water stage, a 12-hour flow was maintained with falling stage from high to low water, followed by 2 hours of low-water flow. Then came determination of flow line, draining of model, and taking of cross sections and photographs.

For all experiments the discharge quantities were: 17 liters per sec. (0.60 sec-ft.) at low water, 172 liters per sec. (6.07 sec-ft.) at mean water, and 548 liters per sec. (19.35 sec-ft.) at high water. These discharges were carefully measured and checked. Elevations of the flow lines as well as of the cross sections of the drained channel were determined by leveling.

For Series 1 and 2 the attempt to approximately equalize the quantities of *geschiebe* introduced and carried off was successful. For Series 3, however, the amount of *geschiebe* carried off exceeded by about 50 per cent the amount introduced, in spite of the fact that for the mean-water run of this series the quantities of *geschiebe* introduced and carried off were the same as for Series 1 and 2. In comparing the results of the high-water runs, this fact is important and must not be overlooked.

FEEDING GESCHIEBE INTO THE CHANNEL

Fresh *geschiebe* was very carefully and methodically hand-fed by a specially trained personnel that had become experienced through numerous preliminary runs. It was fed in at the upper end of the model and was confined at all times to the width of the main channel. The overflow area between levees consisted of cohesive soil carefully tamped, so that the overbank flow, with its relatively low velocities, produced no surface erosion. Refilling of the drained model was always done by admitting water from the lower end. For this purpose a controlled water supply was provided, as shown in Fig. 2. In Figs. 4, 5, and 6, the thalwegs from three series only

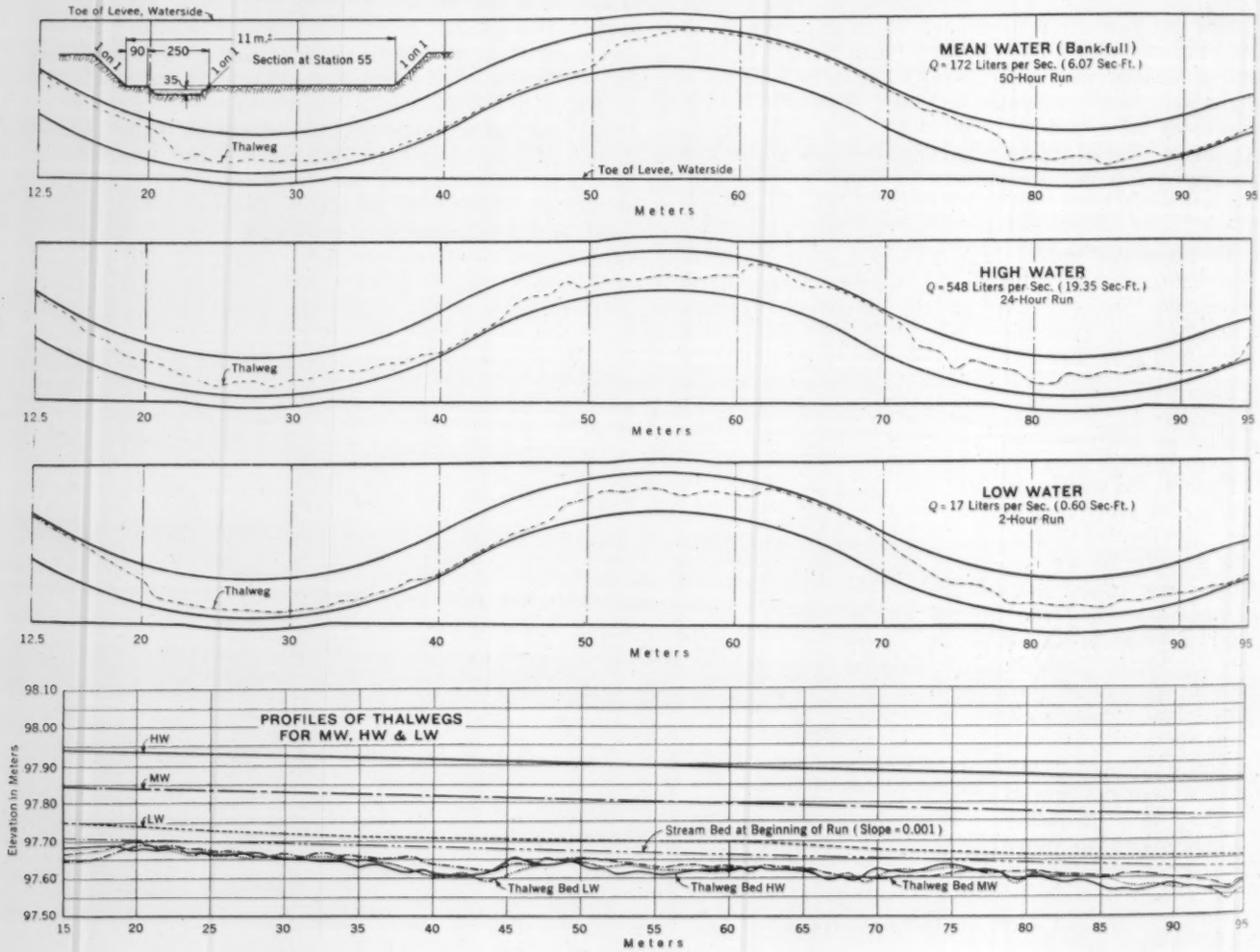

FIG. 4. RESULTS OF TESTS IN SERIES 1, WITH LEVEES STRAIGHT AND PARALLEL

are shown, because the reproduction of complete charts with detailed depth contours would require more space than is here available.

During the course of the experiments, the travel of *geschiebe* was followed by visual observation in so far as this was possible, and in addition such observations were repeated by feeding pulverized red brick into the channel at selected points. All observations showed agreement with the results of earlier experiments in that the *geschiebe* traveled from the lower end of a convex bank, leaving the contiguous concave shore, to the next downstream convex bank on the opposite side, crossing the channel with easy curvature (Fig. 1). In connection with this travel, a sortation of *geschiebe* occurred in agreement with related phenomena in natural streams, whereby the finer material was deposited along the convex bank, while the coarser particles were found along the concave bank. The last-mentioned result is attributable solely to the large scale of the experiments and was not attainable in the earlier tests.

In the small-scale model experiments that have been carried out with fine sand, the bed has invariably shown short, irregular riffles, except in cases where specially selected material was used. In the present experiments the bed surface remained smooth, and the *geschiebe* moved in long bars that had gentle upstream slopes and steep downstream slopes. With rising stage the difference in height between pools and crossing bars showed a general increase, but the length of the latter in the direction of flow showed a general decrease.

The rate at which the *geschiebe* bars traveled was observed to be, on the average, from about 30 to 40 cm. per hour. Riffle formation was limited to the banks of fine sand along the convex shores.

EFFECTS OF LEVEES

The irregularities of the longitudinal profile along the thalweg were greatest at high water for all three experimental series. The low water following high water smoothed out these irregularities only slightly. A supplementary experiment to Series 3, in which a 50-hour mean-water flow followed low water, showed no increased smoothing out of irregularities. In judging the thalweg profiles it should be noted that the absolute bed depth resulting from the initial mean-water flow of each series represents only a transitory condition. It remained for the high-water flow to give the bed a mean absolute depth which, on the whole, remained fixed.

The effects of high water on the river bed were least for Levee System 1 (Series 1), and greatest for Series 3; that is, the difference in depth between the shoalest bar and the deepest pool was least for Series 1 and greatest for Series 3. At the same time, however, the bars were shortest in Series 1 and 3 and longest in Series 2. Of especial importance with regard to the navigable channel is the result that the crossings for Series 2 are the most favorable for navigation. This shows the beneficial effect of spur levees in concentrating the current over the crossings. A comparison of the crossings for Series 1 and 3 shows further that Series 3 acts less favorably on the navigable channel than Series 1. The shoalest low-water crossings are about 5 cm. deep for Series 1 and 3

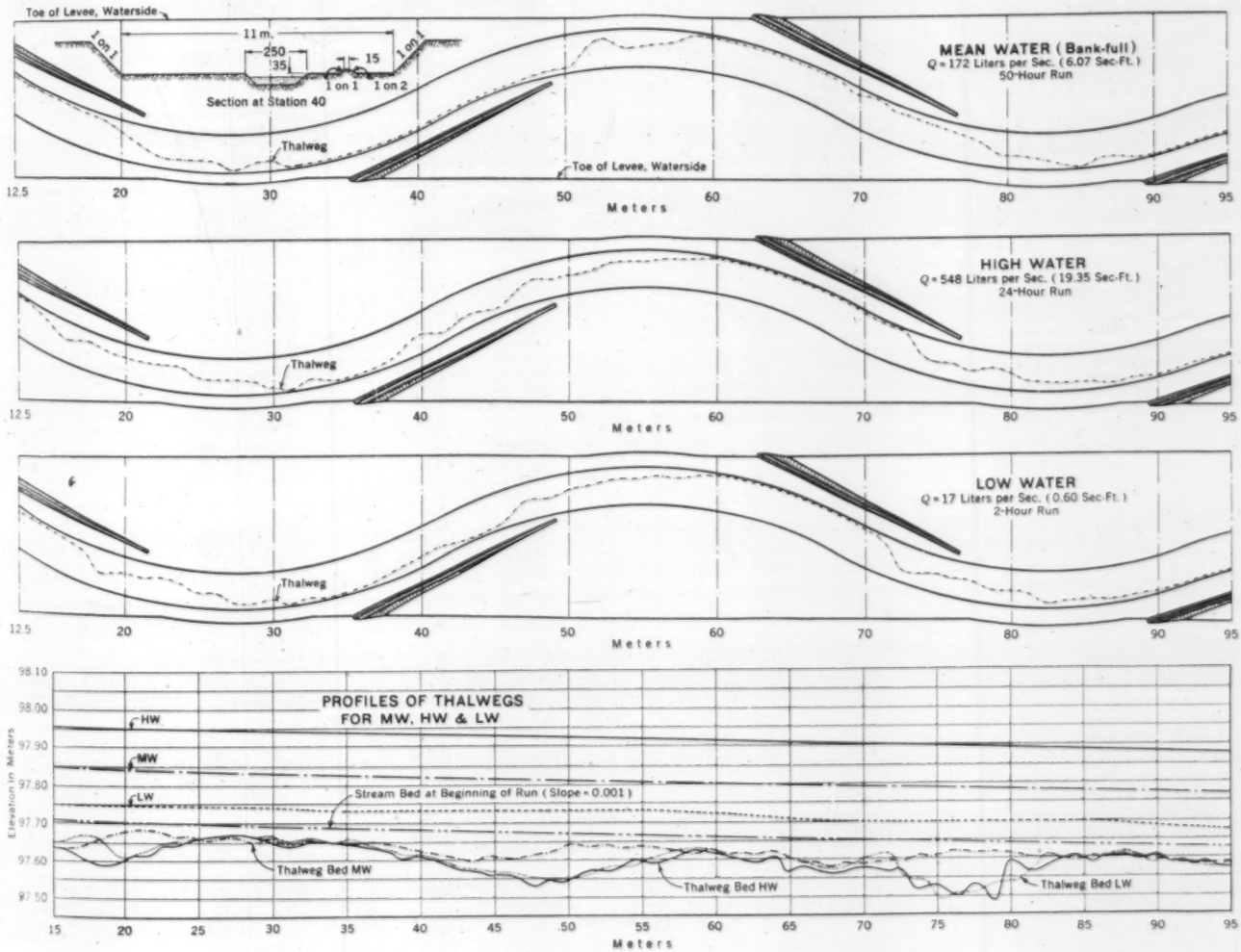

FIG. 5. RESULTS OF TESTS IN SERIES 2, LEVEES STRAIGHT AND PARALLEL; SPUR LEVEES ADDED IN THE FLOOD PLAIN

and about 8 cm. deep for Series 2, again evidencing the beneficial influence of spur levees.

The considerable contraction of the high-water channel in Series 3 produced a raising instead of a lowering of high-water stage, in spite of the fact that, as previously mentioned, the quantity of *geschiebe* carried off in Series 3 exceeded the quantity introduced. Also, the supplementary experiment previously referred to, in which a 24-hour high-water flow followed a 50-hour mean-water flow at the conclusion of the main experiment, Series 2, and in which the quantities of *geschiebe* introduced and carried off were maintained approximately equal, produced no further lowering of the high-water stage. This result is of great significance in judging plans for the purpose of lowering flood stages. It is therefore to be urgently recommended that this important question be thoroughly investigated in large-scale model experiments, in which the characteristics of the particular river, for example, the Mississippi or Hwangho, and especially the nature of the materials transported along the bottom and carried in suspension, be given proper consideration.

RESULTS REVIEWED

The results obtained, particularly those that refer to the effects of leveeing, are attributable solely to the large scale on which the experiments were conducted. Only a large-scale model can give a deeper insight into the formation and transformation of a river bed.

A model experiment in river hydraulics may perhaps be designated as large-scale when the model cross section has the same relation between width and depth as the corresponding cross section in nature, in other words, when the model cross section is undistorted. This desideratum, of course, is not always completely attainable when dealing with large rivers because the depths resulting in a model of economically practicable size would be so small as to make laminar flow likely. Moreover, the upper limit of the experimental scale would usually be dependent on the available time and means.

The recent large-scale tests showed many points of agreement with the earlier small-scale laboratory experiments. Among these is the fact that the earlier Dresden experiments indicated the same thalweg location and *geschiebe* travel as the Walchensee experiments here described.

The results obtained should encourage further large-scale experiments in river hydraulics. For this purpose the experimental plant at Walchensee, with its extensive terrain, large water supply, and excellently trained personnel, is particularly well adapted. Its facilities were utilized during the past summer for a comprehensive study of the problems of the Hwangho River for the Chinese government, a study that is an applied extension of the experiments here described. Actual experiments in nature to determine the course of *geschiebe* travel are now in progress on the Mississippi River.

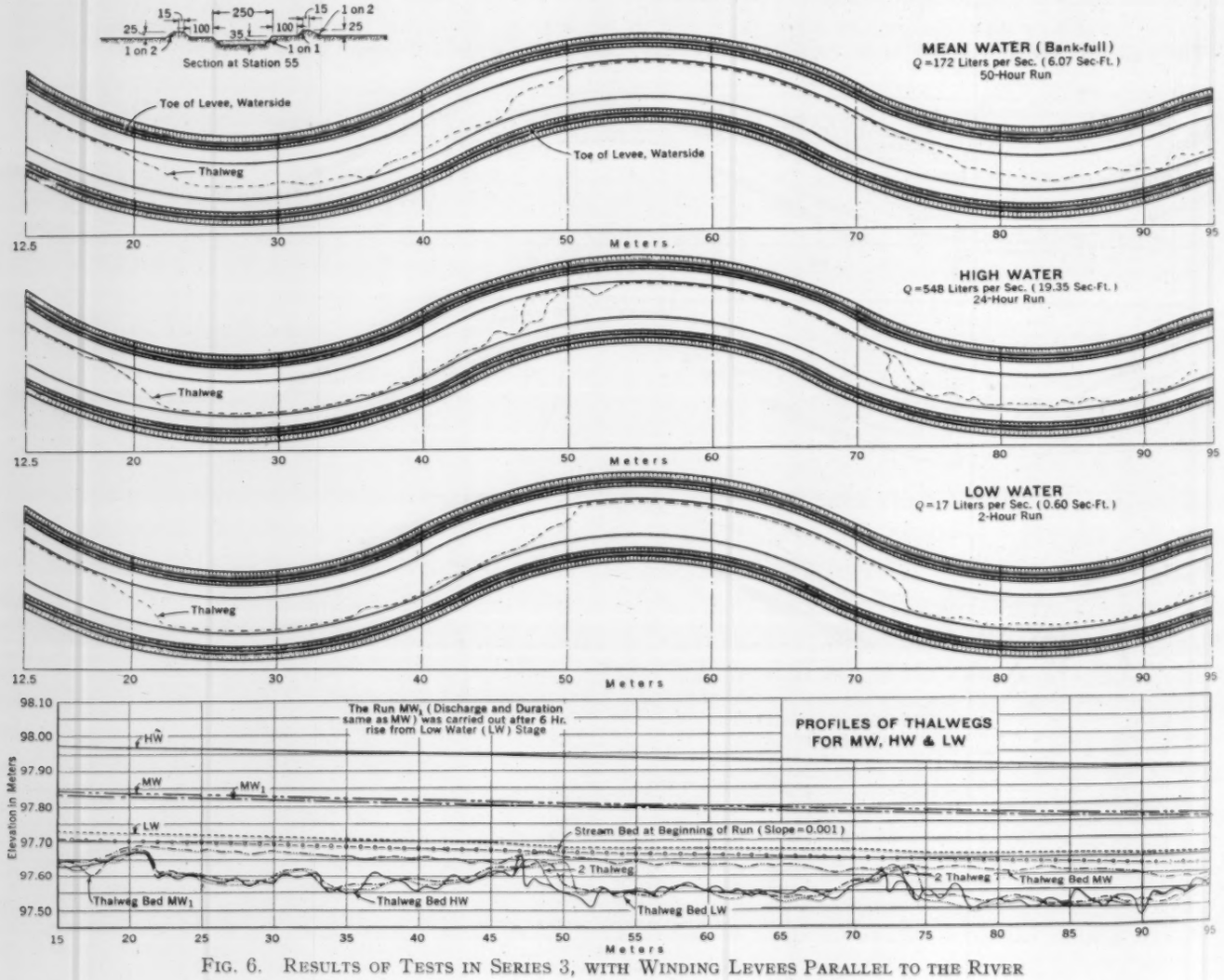

FIG. 6. RESULTS OF TESTS IN SERIES 3, WITH WINDING LEVEES PARALLEL TO THE RIVER

Small Earth Vibrations Affect Foundations

Structural Significance of Jars Produced by Blasting, Pile Driving, Traffic, Rotating Machinery, and Subways

By CLEMENT C. WILLIAMS

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ENGINEERING operations frequently induce vibrations in the earth and, although many investigations have been made on the nature of such vibrations, little definite information exists concerning their structural effects. In this article, Dean Williams brings together a number of scattered observations, adds to them the results of his own researches, and presents conclusions that will be of interest to designers.

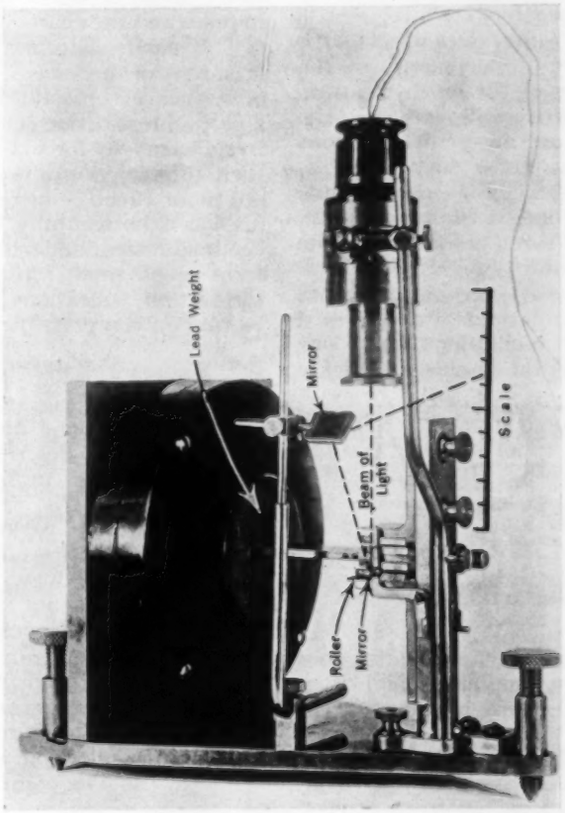
MANY operations for which engineers are more or less responsible produce jars in the adjacent soil that are transmitted through the earth's crust for some distance as vibrations. Such activities as blasting in quarries and excavation; running of steam and electric trains, for example, in subways, over tracks that have ordinary irregularities; hauling of heavy trucks over rough pavements; pile-driving; and the operation of machinery, especially rotating machinery that is slightly eccentric, are all capable of producing vibrations of such magnitude that they might be called earth jars.

Earth vibrations consist of a rather complex wave action and represent a definite amount of energy, which is gradually dissipated by friction as the impulse is spread over larger and larger surfaces with the wave progression. The vibration, as shown by the more elaborate investigations of others, consists of three elements: (1) alternate condensations and rarefactions along the direction of the wave, (2) distortional shearing undulations transverse to this direction, and (3) vertical movements of an undulatory character. Of these, the first is of predominant significance. Although the second and third elements are important factors in larger earth tremors, they are generally not of sufficient magnitude, in the class of disturbances under discussion, to have a serious structural effect. In soft soils, these elements have different velocities of travel.

In the first movement, which consists of alternate compressions and rarefactions, the particles of soil move out from, and in toward, the center of the disturbance. This impulse is similar to sound waves and travels forward at comparable velocities. The energy of the wave, and hence its effects, are proportional to the frequency and the amplitude. For this reason waves of small amplitude but of high frequency may have more serious effects on structures than natural earth tremors that have a lower velocity.

The magnitude of this out-and-in movement of the soil particles has been recorded by several observers and is actually very small, although it may be exaggerated by the senses. Usually the amplitude is between 0.001 and 0.008 in. within 100 ft. of the initial impulse, decreasing approximately as the square of the distance from that point. An amplitude of 0.02 in., observed by Dr. L. Mintrop on the concrete basement floor of an administration building adjoining a power house at Göttingen, and described in *Engineering*, Vol. 93 (1912), page 7, may be taken as a rather extreme case. In his book, *Noise and Vibration Engineering*, S. E. Slocum, M. Am. Soc. C.E., gives about 0.006 in. as the maximum observed vertical movement of a road caused by a motor car going over a pothole.

In the studies of earth vibrations, made at the Universities of Illinois and Iowa under my direction, a small portable seismometer, of a type developed in the physics laboratory at the University of Illinois, was used. A photograph of this instrument is shown. It consisted essentially of a lead mass attached to the center of a thin bakelite disk, so arranged that any movement of the mass in relation to its supporting frame turned a small friction roller, to which a tiny mirror was attached. A beam of light from a bulb fed by batteries struck this mirror and was reflected through an angle by the tilt of the mirror as the roller turned. The angle of this reflected beam of light, measured by the movement over a scale, indicated the amplitude of the vibration. Although this movement could be photographed on a moving sensitized film, the direct reading was found to be more convenient. The instrument was not extremely sensitive but it was capable of detecting the vibrations under investigation. It was calibrated by means of an Ames dial. In Table I is given the magnitude of some earth vibrations—caused by freight and passenger trains and street cars—which have come under my observation.



PORTABLE SEISMOMETER TO MEASURE EARTH VIBRATIONS
A Type Developed at the University of Illinois

TABLE I. MAGNITUDE OF EARTH VIBRATIONS

SOURCE	SPEED	DISTANCE FROM SOURCE In Feet	AMPLITUDE In Inches
Freight train	12 m.p.h.	65	0.0023
	5 m.p.h.	65	0.0009
	8 m.p.h.	65	0.0014
	10 m.p.h.	85	0.0009
Passenger train	.....	40	0.0037
	.....	26	0.0060
	.....	50	0.0040
	20 m.p.h.	140	0.0004
	30 m.p.h.	125	0.0009
Street car	.....	35	0.0023
	.....	60	0.0018

The velocity of travel of the vibration varies with the soil and with the energy of the impulse. In standard works on geophysics, it is shown that the velocity varies inversely with the square root of the density of the soil. The observed velocities for vibrations caused by explosions, recorded in *Seismology*, by John Milne, are shown in Table II.

TABLE II. VELOCITY OF VIBRATIONS CAUSED BY EXPLOSIONS

SOURCE	TRANSMITTING MATERIAL	VELOCITY, IN FT. PER SEC.
Gunpowder	Damp sand	1,000
Gunpowder	Solid granite	3,000
Dynamite	Not stated; probably loose soil	3,600 to 7,200
High explosive	Drift	10,000 to 15,000
High explosive	Solid rock	18,000 to 22,000

The frequency of the vibration depends chiefly on the nature of the original impulse. Vibrations from machinery depend on the speed of the machines, and those from traffic, on the speed of the traffic and the nature of the road surface. From 10 to 30 vibrations per second are common for machinery, while from 5 to 10 per second are usual for railway or street traffic.

The distance from the impulse center over which earth vibrations are effective depends on the energy of the initial impulse and the character of the earth stratum. Although a sensitive seismometer will indicate the passing of a train a mile or more away, observations show that, for all practical purposes, such impulses from passing trains and dropping weights cease to have any structural significance beyond a short distance, generally not exceeding 100 ft. Frozen ground transmits an impulse more effectively than unfrozen.

Earth vibrations from impressed jars in soft soil bear little resemblance to the oscillations of a deformed elastic body. The number of oscillations from one impact is very small, inasmuch as the impulse is quickly

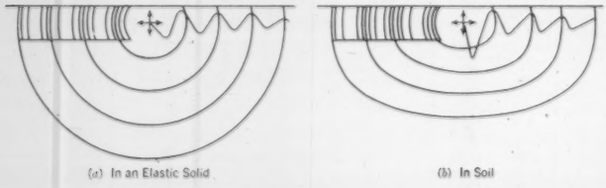


FIG. 1. DIAGRAMS ILLUSTRATING PROPAGATION OF AN IMPULSE

dissipated. Only repeated impacts cause continuous vibrations. Hence the frequency, amplitude, and other characteristics of the jar are directly dependent on the nature of the original impulse.

In an isotropic, elastic solid of indefinite extent, waves from a concussion travel in ever enlarging globes concentric at the point of impulse, as shown in Fig. 1 (*a*). In compressible soils, such globes are somewhat flattened, as a result of imperfect elasticity and lack of constant density, as illustrated in Fig. 1 (*b*). This shape is accentuated also by the fact that, since the velocity of an impulse varies inversely with the square root of the density, and since the density of the earth's crust increases in proportion with the depth, the impulse downward into the earth is rapidly dampened out.

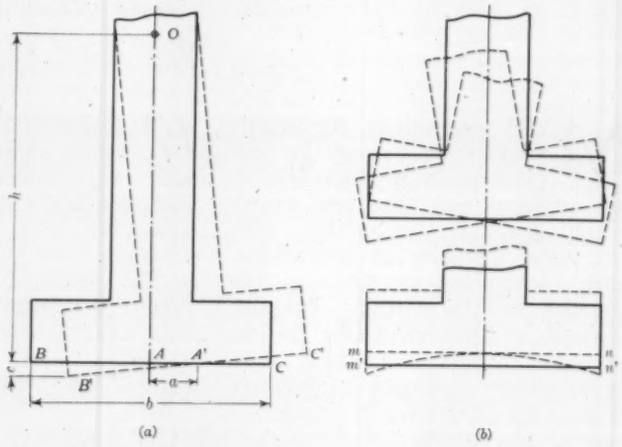


FIG. 2. HORIZONTAL VIBRATIONS ACTING ON A FOOTING

In plastic and granular soils, a deformation of any considerable amount is partly elastic and partly inelastic. The former results from the deformation of the particles themselves without displacement from their relative position; the latter is caused by their displacement in relation to each other. Whether the impulse from a concussion traveling through the soil deforms the soil plastically (fluidly) or only within its elastic range of deformation, depends on the magnitude of the impulse and the character of the soil.

The elastic deformation is recoverable, as is the deformation of any elastic solid, because of the property of resilience. Plastic deformation is not thus recoverable, and restitution occurs only if the pressure of fluidity is sufficient to force the disturbed particles back into their original positions. Therefore, since soil pressures are more effective in restoring particles that have been displaced horizontally than in raising those that have been depressed, and since depression may be caused by a force much smaller than that required to bring about restoration, vibrations through the earth may cause a footing on compressible soil to settle.

EFFECT ON BUILDINGS

The period of vibration of certain reinforced concrete buildings was found by an experimenter to be from 0.5 to 0.65 sec., as described by John R. Freeman, Hon. M. Am. Soc. C.E., in *Earthquake Damage and Earthquake Insurance*, page 473. It is probable, therefore, that small earth vibrations—periods of from 0.1 to 0.2 sec.—do not cause an entire building as a unit to vibrate, but that they do induce vibrations in walls and columns as separate elements. Moreover, the duration of an earth vibration of constant frequency is altogether too brief to permit any cumulative effects from synchronism.

Suppose that a horizontal vibration moves a footing, as shown in an exaggerated form in Fig. 2 (*a*), so that the point A moves to A', rotation being about a mass center or a wall connection represented by an instantaneous center at O. The point B moves to B', being depressed meanwhile to the amount, $c = \frac{ba}{2h}$. If this vibration is repeated and the deformation c at each impulse

exceeds the elastic resistance of the soil, settlement gradually occurs until sufficient compaction is attained to bring the increment of deformation within the elastic resistance.

If, as in Fig. 2 (*b*), the soil at the edges is gradually compressed by successive oscillations, the middle bearing

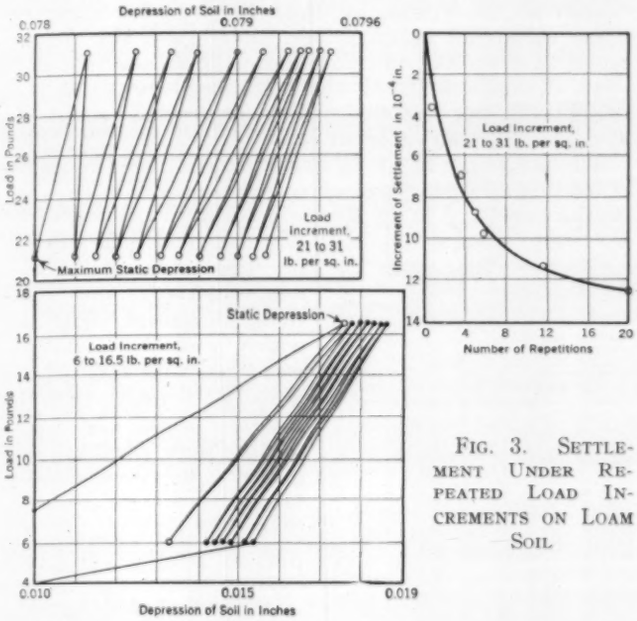


FIG. 3. SETTLEMENT UNDER REPEATED LOAD INCREMENTS ON LOAM SOIL

becomes overloaded, and settlement of the entire footing through a distance *mm'* results. This process will continue until the soil becomes so compacted that the vibration impulse more readily deforms the wall or the footing itself than the soil. Thereafter, the soil has such resistance that the movement induced by the vibration impulse is absorbed entirely in the elastic deformation of the soil and the structural members acting as one elastic system.

CUMULATIVE EFFECT OF EARTH VIBRATIONS

A peculiar characteristic of vibrations transmitted through compressible soils is that they have a cumulative effect, which is almost, if not entirely, lacking in the case of vibrations transmitted through solid rock. Although the velocity of the oscillatory motion of a particle in solid rock is the same both out and in, the velocity in the case of soil is greater in one direction than it is in the other.

Several commonly observed phenomena may be explained by this characteristic of soil vibrations. For example, the curator of the museum in the Natural History Building at the University of Illinois complained that the vibrations induced by trucks on an adjacent street, which was paved with rough brick, caused his specimen containers to slide off the shelves. The extent of these vibrations on each of the four floors of the building was studied by means of the seismometer, and they were found to be of very small amplitude. Similarly, vibrations from street or railway traffic seem to be the chief factor in causing pictures hanging on walls to become askew, as the bottoms gradually work away from the source of the impulse. The explanation is that, on the first half of the vibration, when the acceleration is less rapid, the shelf or wall carries the object with it, while on the more rapid second half, friction is insufficient to cause complete return to the original position, thus making the effect cumulative.

It is reasonable to suppose that this inequality in the acceleration in the two directions of oscillatory motion in soil is a contributing factor in the leaning of walls, of monuments, and of similar structures subject to soil vibrations. I have seen blocks from the top courses in stone masonry bridge piers gradually shaken from their level bedding, a phenomenon that may also be accounted for by this observed inequality of velocity in the vibrations. It is probable also that the cumulative effect of the inequality of accelerations in and out may account in part for the great displacements of earth in earthquakes, since a study of seismograms shows that this inequality exists in some cases.

DEPTH AND DISTANCE AT WHICH VIBRATIONS ARE EFFECTIVE

To illustrate the statement previously made that the increasing density of the earth's crust at greater depths causes vibrations to dampen out rapidly as they go toward the interior of the earth, certain observations may be cited.

Oscillations produced by a 1,200-hp. gasoline engine at 107 r.p.m. are reported to have been more noticeable on the surface at a distance of 700 ft. than they were at a point in a mine 330 ft. away. (*Engineering*, Vol. 93 (1912), page 10.) In the engineering building at the University of Iowa, which lies on a rather steep hillside and extends three stories below the street level at one end, vibrations from heavy electric interurban cars at street level were found to be more severe on the street floor than on the lower ones. Two instances related in *Seismology* by John Milne in connection with astronomical observations, also throw some light on the depth to which jars are transmitted in the earth. When making observations in New Zealand, Gen. H. S. Palmer protected his instruments against disturbance from passing trains 400 yd. distant by digging trenches 4 ft. deep around the piers on which the instruments rested. In making observations in Washington, D.C., H. M. Paul found that the vibrations from trains were almost, but not

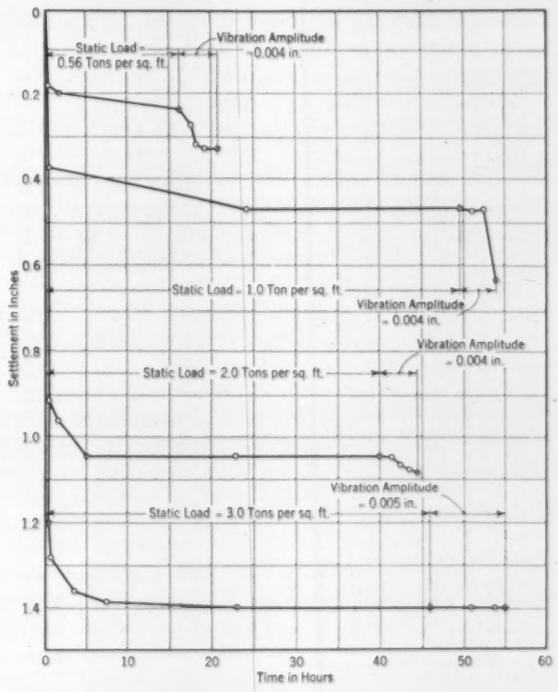

Static Load = 0.56 Tons per sq. ft.
Vibration Amplitude = 0.004 in.
Static Load = 1.0 Ton per sq. ft.
Vibration Amplitude = 0.004 in.
Static Load = 2.0 Tons per sq. ft.
Vibration Amplitude = 0.004 in.
Static Load = 3.0 Tons per sq. ft.
Vibration Amplitude = 0.005 in.
Settlement in Inches
Time in Hours

FIG. 4. BEARING TESTS ON CLAY-LOAM SOIL
Model Vibrated After Static Settlement at 6 Vibrations per Second

entirely, eliminated by a ravine about 50 ft. deep. An intervening hill 50 ft. high was insufficient to destroy surface vibrations.

From these and other scattered observations, it seems probable that disturbances at or near the surface of the earth do not affect the soil at considerable depths and would not, therefore, appreciably deform the soil under footings at depths greater than, perhaps, 25 or 30 ft.

A given load applied intermittently to plastic soil will cause a greater settlement than a static load of the same amount. In like manner, applying and releasing a given increment of load will cause greater settlement than the constant application of a larger load. This is illustrated in Fig. 3, which shows the settlement on ordinary loam soil when the load was changed from 6 to 16.5 lb. per sq. in. and also from 21 to 31 lb. per sq. in. The increment of settlement diminishes with successive applications of the load until equilibrium is established within the elastic resistance of the soil, when no further settlement occurs. Care was taken in performing the tests to apply the load gradually each time so as to avoid impact on the soil. On a damp sand bed, no appreciable increase in settlement occurred after the second application of the load.

The loading increments of 5 and 10 lb. per sq. in. used in these tests would cause depressions on most soils, corresponding approximately to the deformations caused by vibrations of the magnitude under discussion. That is, if an increment of 5 lb. per sq. in. causes a depression of 0.01 in., this corresponds to a modulus of compressibility of 5 ÷ 0.01, or 500 lb. per sq. in. This modulus agrees with the values for loam and clay as ascertained at Iowa State College and shown in Bulletin No. 101 of the Iowa Engineering Experiment Station.

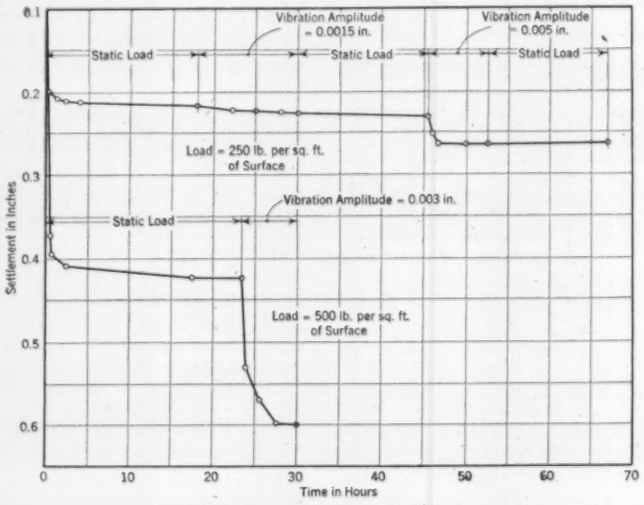


FIG. 5. BEARING TESTS ON MODEL PILES
Model Vibrated After Static Settlement at 6 Vibrations per Second

Conclusive evidence of the effect of earth vibrations could be obtained only by subjecting actual foundations to such vibrations, with all other influences eliminated, and observing results. The observations would have to be repeated for various conditions of soil and load intensity. Obviously, controlled investigations of this sort are impracticable.

Observations of building settlement where vibrations due to the operation of machinery have been present are frequently recorded in the literature of the subject, but there are none that establish irrefutably the part that vibrations play in the settlement of foundations. However, rather numerous observations of the coexistence of vibrations and settlement, and existing competent opinions as to a direct casual relation between the two, afford some evidence that vibrations actually produce settlement.

In order to secure experimental evidence on this problem, a series of tests on laboratory models built on a shaking table were conducted under my direction at the University of Illinois. The vibratory table consisted of a steel plate 48 in. square attached to 6 by 6-in. timbers resting on rollers, which bore on carefully surfaced steel plates. To this table was attached a hinged connecting rod operated by a double-slip eccentric. This was so graduated that any amplitude of vibration between 0.0 and 0.2 in. could be obtained. The eccentric was actuated by a shaft run by an electric motor. The amplitude of the vibrations was checked by means of an Ames dial. By varying the relative sizes of the pulleys and the speed of the shaft, the frequency of the vibrations could be varied. However, since variations in amplitude alone gave the desired range of intensity of vibrations, the laboratory tests were all conducted with the same frequency, that of 6 oscillations per second, which represents about an average frequency of earth jars.

The procedure in the laboratory model tests consisted of loading a bearing area on soil packed in a box resting on the vibratory table, allowing static settlement to be effected, and then subjecting the box to vibrations and observing the additional settlement. The box, which was 2 ft. square, was filled with a clay-loam widely found in the Prairie States. The settlements were observed by means of an Ames dial attached to a rigid frame so that the indicating plunger was in contact with the bearing post.

In the first series of tests, a post 4 in. square resting on the soil in the box was loaded at different intensities and subjected to the vibrations of the table. Then came a period of rest, to allow the static settling to be completed. The settling that takes place under these conditions is given in Fig. 4. Such results would indicate that there is probably a relation between loading intensity and amplitude of vibrations that will produce further settlement in any particular case. That is, on a given soil, with a light load, causing little compaction of the soil, small vibrations will cause additional settlement, while with heavier loads, causing greater compaction, vibrations of larger amplitude are necessary to increase the settlement.

The second series of tests consisted of observing the effect of soil vibrations on a footing eccentrically loaded. An 8-in. square block was subjected to a load of 690 lb. placed 0.75 in. off-center and allowed to settle to equilibrium. It was then subjected for four hours to vibrations with an amplitude of 0.004 in. and a frequency of 6 vibrations per second. The result in every case was further vertical settlement and further rotation of the block, in the proportion of about 0.01 radian for 0.01 in. of settlement.

The third series of tests was made on a slab resting on model piles 10 in. long with a load amounting to 240 lb. of skin friction per square foot of surface of the piles. After loading, the model foundation was permitted to settle to static equilibrium, and was then subjected to vibrations of different amplitudes. The results of two such tests are shown in Fig. 5, from which it is apparent that vibrations of the magnitude of jars caused appreciable settlement of the model. To what extent such vibrations would affect actual pile foundations is of course conjectural. It is probable that they

would cause some settlement in such foundations under buildings if they resulted from subsurface operations that would make the impulse effective over the entire depth of the piles.

Another test was conducted by placing a loaded bearing block in a shallow trench on typical prairie loam soil about 15 ft. from the center line of the eastbound track of a main-line railroad near Iowa City. The location was opposite a frog point, where the jar from passing trains would be accentuated. The 4 by 4-in. post was loaded with approximately 1 ton per square foot of bearing area, and its settling was measured by an Ames dial attached to a surrounding frame. Similar readings were taken at another location 18 ft. from an unbroken track. Trains passed both points at full speed, producing vibrations with an amplitude of from 0.001 to 0.008 in.

The post settled from 0.001 to 0.004 in. at every passage of a train, the total settlement in six days opposite the frog being 0.56 in. and that opposite the unbroken track, 0.46 in. At the former location, passenger trains caused about twice as much settlement as did freight trains, while at the point near the unbroken track, the average was about the same for the two.

In the flexure of a wall or column caused by the horizontal movement of a footing as the result of an ordinary earth vibration, the strain in the wall is too small to cause damage. The stresses induced by such movements are shown by calculation to be of the magnitude of from about 5 to 25 lb. per sq. in. A similar analysis of the strains in a footing slab indicates that the stresses induced by vibrations resulting from minor earth jars are negligible so far as any structural effect is concerned. Such strains are too small even to cause fatigue of concrete by continued repetition.

However, tests in the laboratory on brick-and-mortar specimens indicated that the bond between brick and mortar was frequently broken when they were subjected to vibrations with an amplitude of 0.006 in., so that if brick masonry were subjected to shear stress from vibrations, as, for example, over an opening in a wall, failure of the mortar joints might result.

Where shallow foundations on plastic soils are to be subjected to earth vibrations, allowance may be made for their effect by introducing a certain vibration factor in the estimated loading, corresponding to an impact factor in proportioning ordinary structural members. Such a procedure assumes that in their effects on soil bearing, earth vibrations can be replaced by an equivalent static load. Data on hand are insufficient to determine with certainty the proper magnitude of this vibration factor. It should be largest for plastic soils, on which footings settle slowly, and least, probably zero, for soils, such as sand and gravel, on which settlement occurs almost instantaneously after the application of the load. Where, as in typical soils investigated, under repeated loadings similar to the effects of earth vibrations of ordinary intensity, a footing comes to rest after a total settlement of about three times that caused by an initial period of vibration, and the increment of settlement in that initial period approximately equals the increment of settlement under a 10 per cent increase in load, it may be concluded that 30 per cent of the actual footing loads might properly be added as a vibration factor to provide for earth vibrations of the magnitude under consideration, say an amplitude of from 0.003 to 0.008 in. Inasmuch as vibrations appear to cause little, if any, additional settlement of a bearing plate on sand or gravel, the vibration factor might be taken as zero for such cases.

CONCLUSIONS

1. The total settlement of shallow foundations on plastic soils may be increased when the structure is subjected to earth vibrations of the magnitude caused by trains, heavy street traffic on rough pavement, blasting, pile driving, and the operation of heavy rotating machinery. This increment of settlement will usually be small.

2. The amount of the settlement from this cause depends on the energy of the impulse, particularly the amplitude and the character of the soil.

3. Owing to the cumulative effect of such vibrations, inequalities of bearing will be accentuated in the amounts of the settlement. Such inequalities as eccentricity of load on footings and improper distribution of supporting areas between dead and live loads, will increase local settlement when the footings are subjected to vibrations.

4. Where shallow footings are to be subjected more or less continuously to earth vibrations, their effect should be considered as a vibration increment to be added to the estimated loads in proportioning the bearing areas, or some device, such as pre-compacting, should be used to increase the resilience of the soil.

5. Foundations on the less plastic soils, such as sand and gravel, probably will not be appreciably affected by earth jars.

6. Deep foundations, bearing at considerable depth below the level of the impulse, will probably not be affected by vibrations from earth jars at the surface.

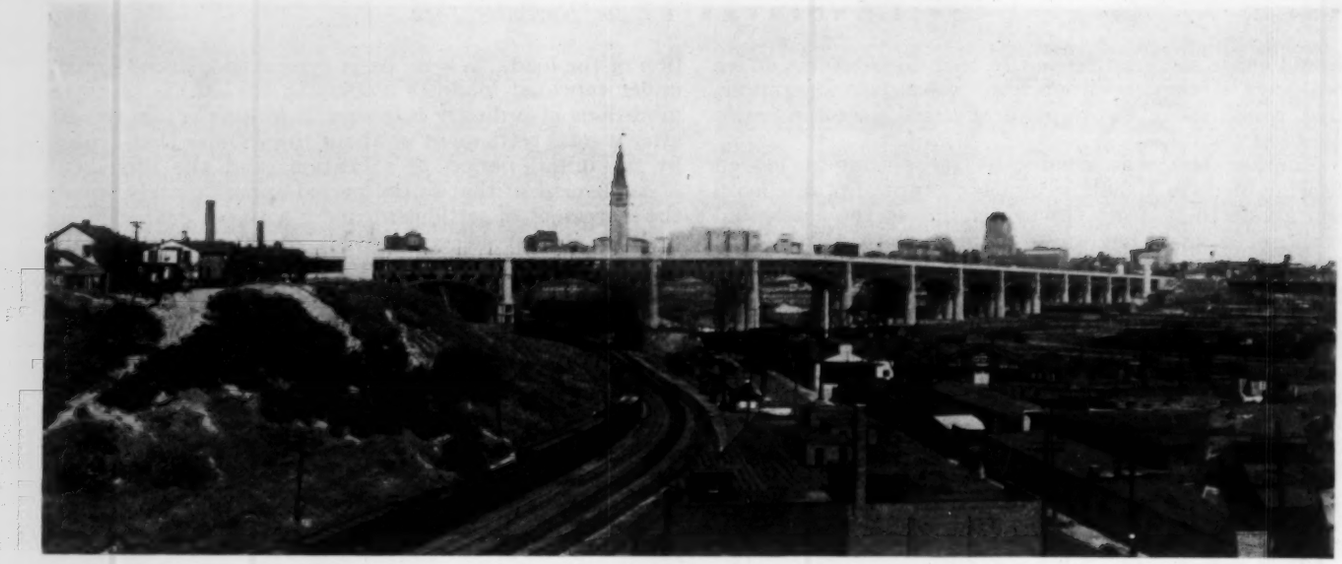
Another device that may be used to prevent settling under vibrations is pre-compacting the soil by tamping or rolling. If a plastic soil, intended to carry a given load, is pre-compacted an amount corresponding to two or three times that intensity, settlement would probably be eliminated since, as in Fig. 3, a repetition of the lower limit of a load increment is observed to fall within the elastic range of the supporting capacity of the soil.

Pre-compacting creates a sort of slab of compressed soil of increased resilience, which will carry the increment of load equivalent to vibration effect without further compaction within itself, and at the same time distribute the bearing to the underlying soil with an intensity sufficiently diminished to cause no settlement in those layers.

EFFECT OF ROLLING OR TAMPING

Relatively simple devices for dropping a weight, for hand tamping, or for rolling may be used to impose the equivalent of 5 or 6 tons per square foot on soil. For example, if a 50-lb. weight is dropped 2 ft., and this energy is expended over a soil area of 0.5 sq. ft. with $^1/_4$-in. depression, the result would be equivalent to an intensity of 5 tons per square foot. Such pre-compacting might be expected to prevent settlement under loads of 2 tons per square foot even though subject to earth vibrations, because the increased resilience of the soil would be sufficient to bring the increment of pressure within the elastic resistance of the soil. Pre-compaction will not be effective unless it amounts to more than the load that would be produced by the actual building.

The investigations discussed in this article were conducted largely by graduate students in civil engineering under my direction at the University of Illinois and at the University of Iowa, successively. Most of the laboratory and field work was done by H. Townley Heald at the former institution, and by Bernie A. Trice at the latter. Many helpful suggestions were made by Dr. F. R. Watson, Professor of Experimental Physics at the University of Illinois. I wish to acknowledge my indebtedness for their contributions to these studies.



LORAIN-CARNEGIE BRIDGE OVER CUYAHOGA VALLEY, CLEVELAND

Lorain-Carnegie Bridge in Cleveland

Cantilever Trusses Constructed of Copper Bearing Silicon Steel

By WILBUR J. WATSON

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SENIOR PARTNER, WILBUR WATSON AND ASSOCIATES, ENGINEERS, CLEVELAND

FROM southeast to northwest, Cleveland is traversed by the winding Cuyahoga River Valley which, while it provides the railroads with an effective entrance to the city, cuts it into two distinct districts as far as vehicular traffic is concerned. To provide crossings over the river and its wide valley, several bridges have been built, notably the Detroit-Superior Bridge near the lake front and the Central Viaduct to the south. After 25 years of study on a viaduct to connect Lorain Avenue on the west of the river with the district to the east, in the course of which time the project was once abandoned after bonds had actually been voted for construction, the citizens of Cleveland are opening, the first week in November, a $6,500,000 viaduct 5,865 ft. long, with its eastern terminus at Central Avenue. Dr. Watson's interest in the project has been continuous since its inception. As consulting engineer for the present structure, he can speak with authority concerning it.

FOR many years the project of constructing a high-level bridge over the Cuyahoga Valley, connecting Lorain Avenue on the west with the east side of the city, was discussed—almost as long as that for a new Union Station, now realized. Much of this discussion hinged about the proper location of the eastern approaches.

EARLY STUDIES MADE

About 25 years ago, I made some studies for a viaduct from Lorain Avenue direct to the southwest corner of the Public Square (Fig. 1) but they did not meet with approval, largely because the route went through the main building of the Cleveland Telephone Company, the cost of removing which at that time was thought to be prohibitive. Later studies were based on the location of the eastern terminus at Huron Road. A bond issue was actually voted to construct such a bridge in 1921, but the project was abandoned, largely on account of a taxpayers' suit attacking the issuance of the bonds, but also partly, no doubt, because of the development of plans for the railroad station. The wisdom of locating the eastern approach so close to the terminal was questionable.

In 1925, John W. Leadley was engaged to make a report to a special committee of the City Plan Commission on the proposed bridge. It was then designated the Lorain-Carnegie Bridge because Carnegie Avenue had been widened into a main thoroughfare, and it was felt that the new bridge should connect with it in order to provide a by-pass for through traffic around, and south of, the business section and so relieve the congestion in that section and on the overloaded Detroit-Superior Bridge. Since Carnegie Avenue extended westward only to East 22d Street, it was necessary to correlate the bridge project with its extension. To accomplish this purpose several plans were proposed. That of Mr. Leadley provided for the eastern approach at Eagle Avenue, the extension of Carnegie to run south of the old Erie Street Cemetery. To carry out this plan properly would require, it was found, a bond issue of some 15 million dollars, and it was defeated.

In order that an unprejudiced study might be made of this question of location, a Citizens Fact Finding Committee was organized in 1927, at the suggestion of the Chamber of Commerce and other civic bodies. This committee made an exhaustive study of the factors involved, and finally recommended that the eastern terminus be located at Central Avenue; that a single deck be built first, and provision made for a future lower deck to carry street cars and trucks; and that adequate provision be made for the separation of traffic between the proposed new bridge and the existing Central Viaduct. The recommendation of the committee also stated that the main approach to the bridge should be at the level of Ontario Street.

In order to meet these requirements, the consulting engineers and architects first proposed to carry the through traffic to and from the new bridge over Ontario and

Woodland streets and Broadway, but this did not satisfy the requirement of the committee that the main roadway should meet the grade of Ontario Street. Plans were then made to carry the traffic to the old Central Viaduct in a subway, but it developed that this arrangement would interfere seriously with probable future street railway subway construction and was not warranted by traffic conditions then existing, or to be expected for some decades. Therefore it was determined to develop a first stage of the project that would fit into a future second stage. This first stage contemplates the moving of Central Avenue about 80 ft. to the north where it intersects Ontario Street, thus providing sufficient width in Central Avenue at this point to entirely separate the two streams of traffic from the new and the old bridges. The second stage contemplates the development of a circle at the intersection of Broadway and Central, Woodland, and Ontario streets, which will provide a one-way gyratory movement for all traffic lines intersecting at that point. When this second stage is carried out, it is expected that all street railway tracks will be underground.

Traffic studies conducted by Dr. J. Gordon McKay, Director of the Bureau of Highway Research for Cuyahoga County, indicated that the probable future maximum traffic through this circle would be north and south and not east and west; therefore an elevated roadway carrying Broadway (which runs north and south) across this circle would serve traffic needs better than an elevated roadway going east and west. However, the proposed circle will serve to take care of the maximum possible traffic for a long time.

Estimates of the probable traffic on the streets adjacent to the new bridge, made by Dr. McKay, and based on traffic counts secured at that time, are as follows:

STREETS	VEHICLES PER DAY
Lorain-Carnegie Bridge:	
Without the Walworth Avenue connection	12,000
With the Walworth connection	14,500
Central Viaduct	10,000
Broadway (future)	23,700
Eagle Avenue	10,700

It is difficult to predict with precision the probable traffic over a new artery such as this, and it is expected that within a short time the bridge traffic will exceed these estimates. The present traffic on the Detroit-Superior Bridge is approximately 70,400 vehicles per day. It is estimated that the proposed Main Avenue Bridge will carry about 28,000 per day, many of which will be taken from the Detroit-Superior Bridge.

Location of the piers for the new bridge was dictated largely by consideration of property damages. Starting at the east bank of the valley, the structure passes over the tracks of the Wheeling and Lake Erie Railroad,

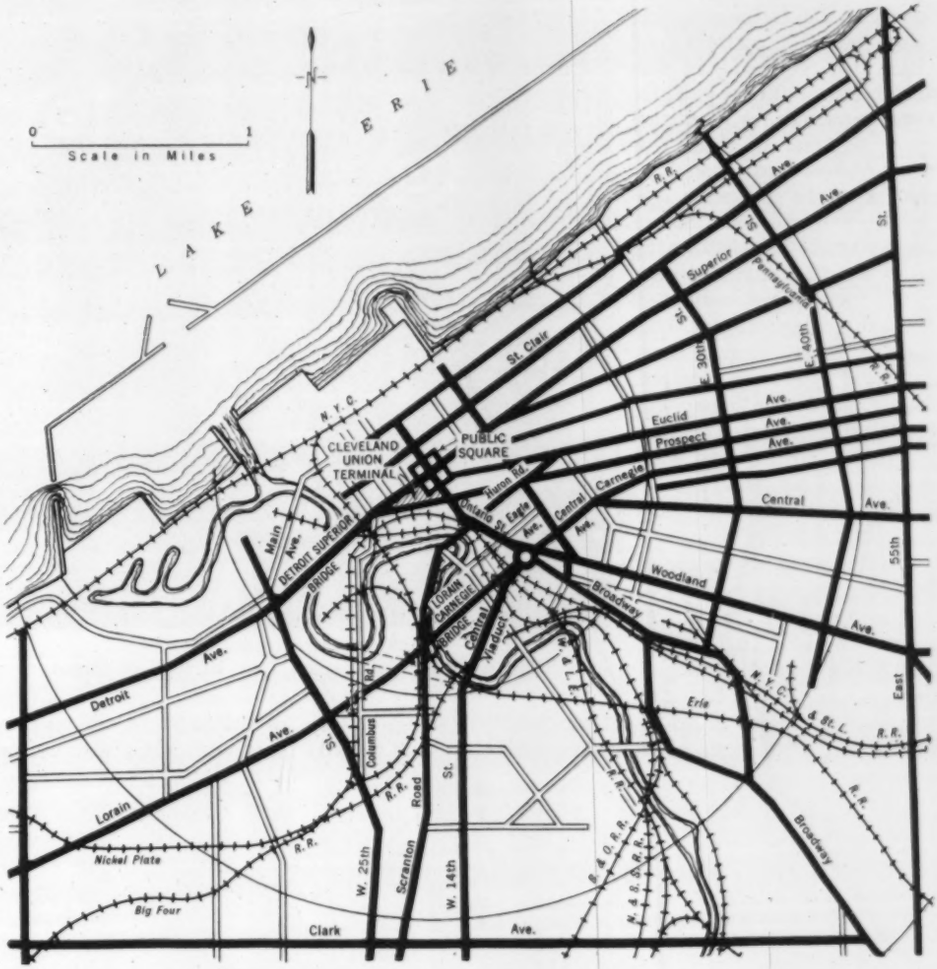


FIG. 1. LOCATION OF THE LORAIN-CARNEGIE BRIDGE, CLEVELAND
Its Relation to the City's Road Net Is Shown

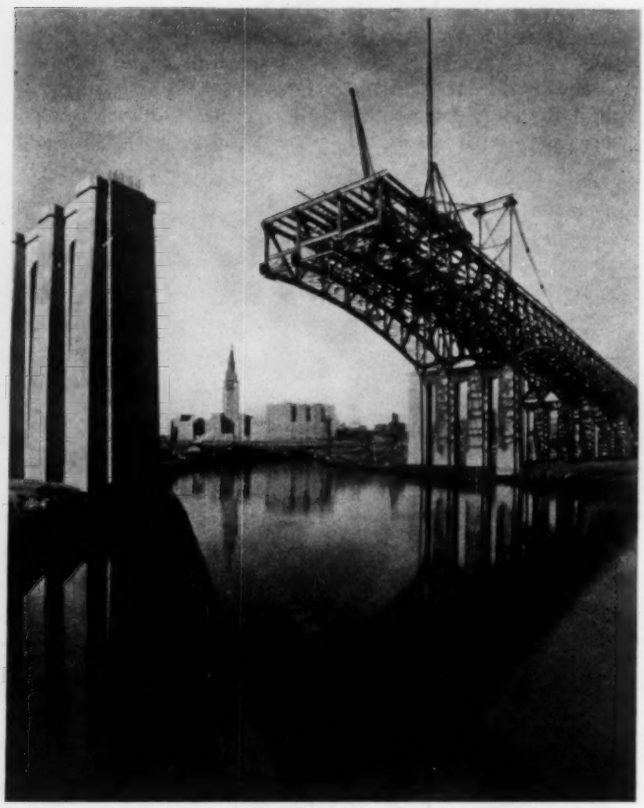
then over Canal Road, an important street, next over the tracks of the Baltimore and Ohio Railroad, and thence over numerous yard tracks of the Big Four railroad to the river. On the west side of the river lie the tracks of the Erie Railroad, then the main line of the Big Four, and the Erie dock tracks.

The problem of so locating piers as to damage these yard facilities as little as possible, to avoid interference with city streets, and to cause a minimum disturbance to industrial plants, was a complicated one. Nevertheless it became possible to establish a fairly uniform spacing of piers, gradually increasing in span length as the river was approached.

To add to the difficulties, it was required that the structure should be so designed as not to interfere with the carrying out of the river-straightening program of the city. This proposed river cut-off lies west of the west pylon of the bridge, and the problem was solved by designing this part of the structure in such a manner that trusses can be inserted under the floor system of the bridge, the posts removed, and the excavation for the cut carried out without interrupting traffic over the bridge.

The superstructure of all spans of this bridge between pylons is carried on steel trusses of the cantilever type, alternate spans carrying suspended trusses. The longest span is that over the river, 299 ft. long, which comprises 12 panels, of which the central six are suspended. These cantilever trusses differ from the usual design in that the lower chords are curved to give a more pleasing appearance to the structure. Comparative estimates made by the engineers on preliminary plans indicated that this design was but slightly more heavy than the usual type with straight chords, and the designers felt that the additional weight of metal was warranted. The increased weight of structural steel was about 6 per cent.

Studies were also made of the comparative economy of continuous and cantilever trusses, which indicated that there was a saving of about 4 per cent in favor of continuous trusses if no provision had to be made for differential settlement of the piers, and that this would be reduced to about 2 per cent if a differential settlement of 1 in. were assumed. Because of the treacherous character of the foundation material, the designers considered that it was unwise to use the continuous truss.



LORAIN-CARNEGIE BRIDGE DURING CONSTRUCTION

The citizens' committee was desirous that this bridge should have architectural character as well as good engineering design. The engineers have had the assistance and advice of F. R. Walker, of Walker and Weeks, Architects, in determining the general design and the details of the railings and pylons.

ARCHITECTURAL FEATURES

The architectural features are essentially the curved lower chords of the trusses, the concrete fascia wall carrying the piers up to the roadway, the concrete pedestals between the trusses, the stone and aluminum railings, and the four massive stone pylons decorated with carved figures of heroic size. The extension of the piers to the upper-deck level was not strictly essential to the construction, but was desirable for certain reasons apart from architectural considerations. It was necessary, on this structure, to provide unusually extensive facilities for the carrying of water and gas lines, and for electric conduits (Fig. 2). Where these utilities pass over the piers, working chambers for splicing cables have been placed in the pier extensions. The use of aluminum panels for the bridge railing was a new departure.

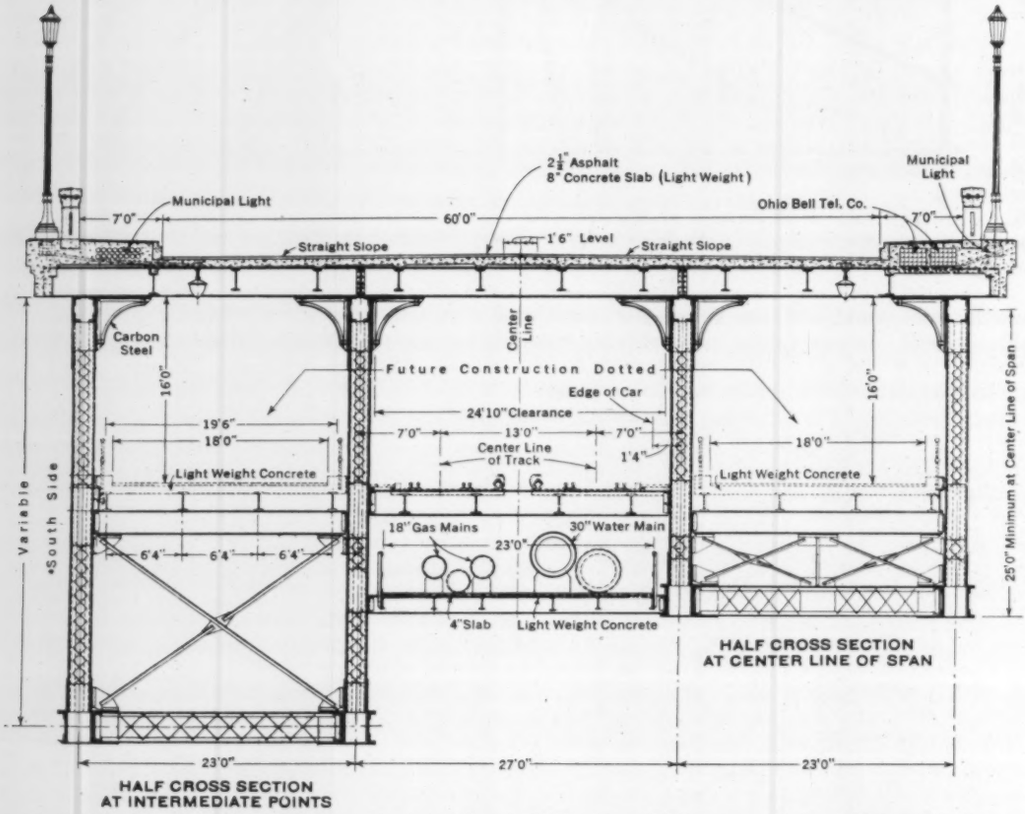


FIG. 2. TYPICAL CROSS SECTION OF THE BRIDGE; PROVISION MADE FOR FUTURE RAPID TRANSIT

PILE FOUNDATIONS

Wash borings taken at each pier location showed fine sand and gravel present approximately between elevations −25 and −43 and then clay, generally increasing in hardness with the depth, but quite variable. Sand mixed with some clay was found at the west hill for a depth of about 40 ft. above the clay.

At the east end the clay is at an elevation of about +30 at Canal Road, and the hard clay at about +16. At the river the clay line was found at about −40, and hard shale (the underlying "rock") at −164 on the east side of the river and −159 on the west side. At the boring on the east side of the river, gas was found at about elevation −100. In this connection it may be of interest to note that the river piers of the Detroit-Superior Bridge are at elevation −48, in a stiff blue clay which settled, or rather compressed, about $1\frac{1}{2}$ in. under a dead load of 5.62 tons per square foot.

ORNAMENTAL PYLONS
Two Heroic Figures at Each End of the Bridge

PILES USED IN CLAY

When clay was uncovered at −42, in the foundation for the west river pier, it was so soft that it was found necessary to drive 440 wooden piles 35 ft. long. This was also done for the east river pier. These river piers were carried to elevation −42. From previous experience as well as from the boring data, it was expected that a hard clay would be found at this depth and that the footings could be laid in the dry. The dead load on these footings is about 3.75 tons per square foot, and the combined dead and live load is about 4.30 per sq. ft.

Comparative studies were made of the cost of various types of foundations for these piers, and the method adopted was found to be much less expensive than cylinders or caissons carried to rock, the only practicable alternative. These piers rest on a concrete mat (Fig. 3), 33 ft. 6 in. by 100 ft., and 7 ft. thick, heavily reinforced. On this mat are carried hollow shafts, 16 by 20 ft. at the base, tapering to about 8 ft. 6 in. by 17 ft. under the coping. These shafts have walls 3 ft. thick at the base and 2 ft. thick at the top. They are about 114 ft. high and have a side batter of 1 in 50 and an end batter of from about 1 in 35 to 1 in 42 above ground. The enclosing cofferdams were constructed of steel sheet piling about 38 by 104 ft. and about 60 ft. deep, with steel bracing, allowing all concrete to be placed out of water.

DIAPHRAGMS IN PIERS

Two interesting details of these piers are the horizontal diaphragms, 5 in each pier, at various levels and the battered interior surface between low and high water to prevent internal ice pressure, which might occur from the freezing of water held within the shafts.

All piers except Pier 12 and the river piers were supported on concrete piles, each of which carries a dead load of not more than 30 tons per pile, and a combined dead and live load not to exceed 35 tons per pile. Pier 12 is carried by spread footings on stiff clay. The east and west abutments and retaining walls are founded directly on sand.

PERMISSIBLE LOADS

Before determining the live loads and unit stresses to be used for this project, the engineers made studies of various modern vehicles and the loads carried by them. They found that touring cars, placed as close as they can travel at a reasonable speed, produce a load of from 30 to 35 lb. per sq. ft.; and 20-ton trucks spaced 38 ft. on centers on a 9-ft. lane produce a load of about 117 lb. per sq. ft. This spacing would require slow speeds and consequently a low impact. The average load for congested traffic consisting of mixed trucks and passenger cars may be taken at 55 lb. per sq. ft.

Assuming the average span of 200 ft., eight lines of

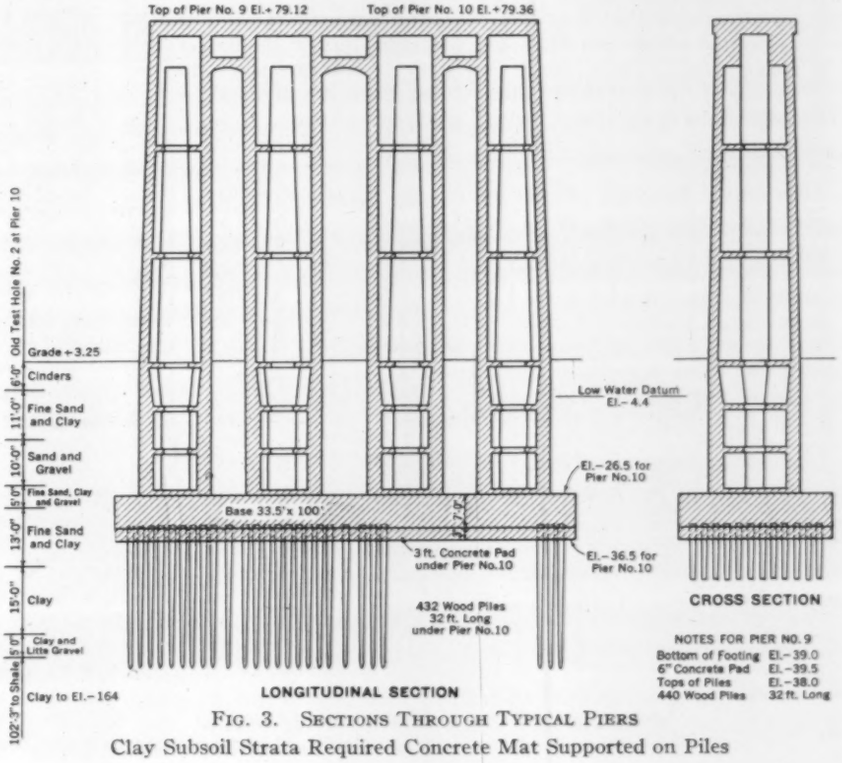

Top of Pier No. 9 El.+79.12
Top of Pier No. 10 El.+79.36
Old Test Hole No. 2 at Pier 10
Grade +3.25
6'-9" Cinders
11'-0" Fine Sand and Clay
10'-0" Sand and Gravel
5' Fine Sand, Clay and Gravel
13'-0" Fine Sand and Clay
15'-0" Clay
5' Clay and Little Gravel
102'-3" to Shale
Clay to El.−164
Low Water Datum El.−4.4
El.−26.5 for Pier No.10
Base 33.5'x 100'
7'-0"
3 ft. Concrete Pad under Pier No.10
El.−36.5 for Pier No.10
432 Wood Piles 32 ft. Long under Pier No.10
LONGITUDINAL SECTION
CROSS SECTION
NOTES FOR PIER NO. 9
Bottom of Footing El.−39.0
6" Concrete Pad El.−39.5
Tops of Piles El.−38.0
440 Wood Piles 32 ft. Long

FIG. 3. SECTIONS THROUGH TYPICAL PIERS
Clay Subsoil Strata Required Concrete Mat Supported on Piles

vehicular traffic, two electric railway tracks, and two 5-ft. walks, the equivalent live loads given by four well-known specifications are as follows:

SPECIFICATION	LOAD IN LB. PER SQ. FT.
Ohio State	98.5
American Railway Engineering Association	66.2
American Association of Highway Officials	105.0
New York Port Authority	72.0

The live loads assumed for this project were equivalent to 83.2 lb. per sq. ft., based on similar assumptions, and were as follows:

LOCATION	LOAD	IMPACT FACTOR
Roadway Slabs	20-ton trucks	+50 per cent
Highway floor beams	20-ton trucks	+25 per cent
Railway stringers	60-ton cars	+60 per cent
Railway floor beams	60-ton cars	+50 per cent
Sidewalks	100 lb. per sq. ft.	None
Railings (horizontal force)	150 lb. per lin. ft.	None
Trusses and substructures:		
Walks	60 lb. per sq. ft.	None
Roadways	85 lb. per sq. ft.	None
Railway tracks	1,500 lb. per lin. ft.	None

For wind loads, a lateral force of 30 lb. per sq. ft. was assumed to act on $1^1/_2$ times the vertical projection of one truss, including the floor system and railing, and on one-half the vertical projection of each truss in excess of 2. Also a wind load of 200 lb. per lin. ft. was assumed to act on the live load of the upper deck, and 300 lb. on that of the lower. A longitudinal braking force of one-tenth the live load was added for each deck.

When the lower roadways are completed, the total dead load on the bridge superstructure will be about 34,000 lb. per lin. ft. of bridge, and the total live load, about 13,500 lb. per lin. ft.

DESIGN OF CONCRETE WORK

All concrete piles are of the precast type, 16 in. square, reinforced with four $0^7/_8$-in. round bars. They vary in length from 30 to 45 ft., and were driven practically to refusal. Driving was done by a hammer weighing 5,000 lb., with a 42-in. stroke, and the penetration obtained was about 5 blows per inch for the last foot or better. In many cases it was found necessary to use the water jet in order to get these piles down, but in all cases the last 3 to 5 ft. were driven without jetting. The water jet used operated under a 200-lb. pressure through a $0^5/_8$-in. nozzle.

Concrete footings were made of 1:2:4 concrete, generally with river sand and limestone aggregate. Tests of standard cylinders of this mix gave an average strength of over 4,000 lb. per sq. in. at 28 days. Pier concrete was composed of $1:1^1/_2:3$ concrete of similar proportions. Tests of standard cylinders yielded an average strength of over 5,000 lb. per sq. in., with a slump of from 3 to 5 in. The concrete of all the piers is exposed up to the bridge deck, except that of the two pylon piers, which are faced with stone.

FOUR LINES OF TRUSSES RATHER THAN THREE

As noted in the description of the general design, the entire superstructure of the bridge is structural steel, consisting of a series of cantilever spans which carry steel transverse I-beams directly on the upper chords. Into these the I-beam stringers, placed 6 ft. 10 in. on centers, were spaced.

Four lines of trusses were used. Although comparative studies indicated some advantage in economy of metal by using three lines instead of four, this arrangement did not work out well for the lower deck, which required three spaces, one for street railway or subway tracks, and two for the future truck roadways. While all these facilities are not installed at the present time, full provision is made for their future installation. The main trusses have a minimum depth of 25 ft. and a maximum of about 50 ft.

In general, the lower chords are composed of two 30-in. plates and four angles; the upper chords of two 24-in. plates and four angles; and the web members of two plates from 16 to 25 in. wide, and four angles, all double laced. Suspended spans are secured to the upper chords of the cantilevers, with a lower chord strut to carry the lateral loads only.

STRUCTURAL STEEL CONTAINS COPPER

All the material in the main members is silicon steel, and all that in the lateral and sway bracing and in other secondary members is carbon steel. The carbon and silicon steel conformed to the standard specifications of the American Society for Testing Materials, except that 0.2 per cent of copper was added to all the steel used in this bridge, to increase its resistance to corrosion. In tension the allowable working stress in the carbon steel was 18,000 lb. per sq. in. That in the silicon steel was raised to 25,000 lb. per sq. in. Workmanship requirements followed closely the standard specifications of the American Railway Engineering Association for highway bridges.

Throughout, the roadway was paved with 3 in. of asphalt, carried on a concrete slab composed of light-weight concrete and reinforced with fabricated units. Sidewalks are of stone flagging 2 in. thick, laid in a bed of asphalt mastic $0^1/_2$ in. thick. The curb is unusual, having a total height of 17 in. above the gutters, the face toward the roadway being offset 4 in. at a height of $10^1/_2$ in. above the gutters, forming a 6-in. step. The purpose of this was twofold: first, to protect wheel hubs, and second, to secure sufficient depth under the sidewalks to take care of the necessary telephone and lighting conduits. The curbs are of granite 10 in. thick by 20 in. deep, with a notch 4 in. wide by $6^1/_2$ in. deep, and are sawed on four sides to insure a uniform size and smooth surfaces for damp-proofing.

DATA ON THE STRUCTURE AS A WHOLE

In a project of this size it is of interest to visualize the general dimensions and costs. The length of the project, from Ontario Street on the east to West 25th Street on the west, is 5,865 ft., of which the distance between pylons at each end of the cantilever truss spans is 2,886 ft. The individual spans vary from 132 ft. to 299 ft. At each end, the main part of the viaduct is reached by approach fills and steel trestles. On the west end, the approach passes over the tracks of the Cleveland Union Terminal and over Columbus Avenue on two separate structures. At the Cuyahoga River the clearance is 180 ft. between fenders horizontally and 93 ft. vertically for a 120-ft. width at top.

For Cuyahoga County, F. R. Williams is County Engineer, and A. M. Felgate, Bridge Engineer. I was consulting and designing engineer, and F. R. Walker was the architect. The viaduct was built for Cuyahoga County by the Lowensohn Construction Company, contractor for all work except the structural steel and the two river piers. The structural steel was fabricated by the Mount Vernon Bridge Company, and the river piers were built by the Walsh Construction Company. The construction cost was $4,750,000 and real estate and property damage together totaled approximately $1,750,000. There remains in the treasury $1,500,000 of the $8,000,000 bond issued voted by the people.

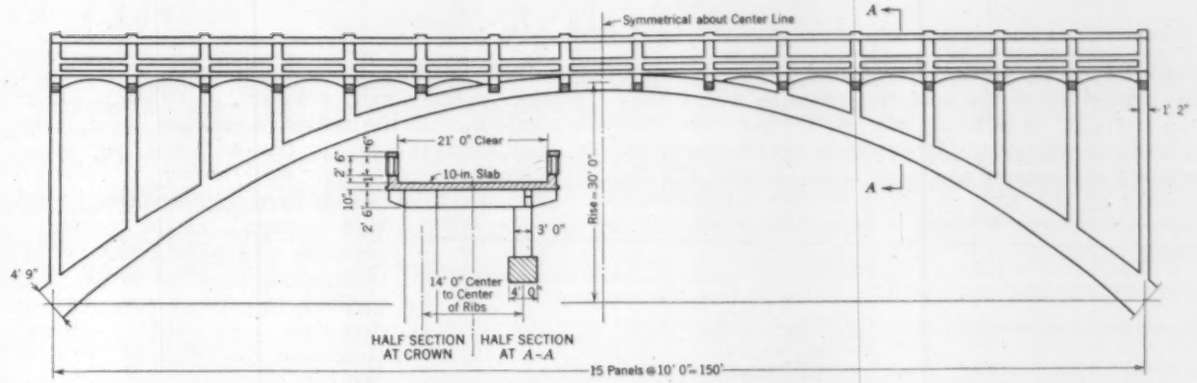


FIG. 1. LOW-DECK DESIGN FROM WHICH MODELS WERE PREPARED
Elevation and Cross Sections

Deck Participation in Concrete Arch Bridges

Celluloid Models Indicate Great Modification in Rib Stresses Produced by Integral Deck and Spandrel Columns

By A. H. FINLAY

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STUDIES of the effect of deck participation, or integral arch action, have been conducted for a number of arched structures, among them the Ashtabula Viaduct in Ohio, in 1926; the Market Street Bridge at Harrisburg, Pa., in the same year; and the Yadkin River Bridge in North Carolina, in 1929. The results of the investigation conducted as a part of the program of the Society's Committee on Concrete and Reinforced Concrete Arches were published in Bulletin 226 (April 1931) of the Engineering Experiment Station of the University of Illinois. At the present time the tendency is toward integral deck construction and many state highway departments have considered deck participation in their designs. Professor Finlay's article is of practical application in calling particular attention to the effect of expansion joints in the deck and in pointing out errors that may creep into designs when the action of the deck is neglected.

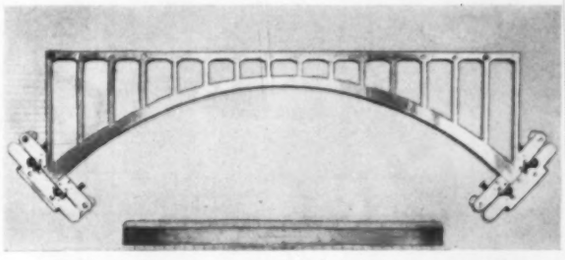
IT IS generally well known by designers of arch bridges that there is an interaction between the deck, the spandrel columns, and the arch ribs of a bridge that has been cast as a monolith. Usually, however, designs have been based on the assumption that the loads are applied directly to the rib and that its behavior is not influenced by the spandrel columns and deck. It is hoped that this article may bring out certain factors affecting arch design, which in the past have often been vaguely felt rather than clearly visualized.

To determine the manner in which the concrete deck and spandrel columns, poured integrally with the arch rib, affect the action of a bridge as a whole, I have made the necessary analyses, using the mechanical method developed by George E. Beggs, M. Am. Soc. C.E. Dead-load, live-load, and temperature stresses were investigated, and influence lines were constructed for thrust, shear, and bending moment at the crown and springing line of a 150-ft. arch having in one case a low deck and in the other a high deck. In all cases the results have been compared with those obtained mathematically by the conventional method, which considers the rib alone.

The results are predicated on complete continuity of the structure before the arch centering is struck. In so far as this condition may be modified in practice, the results must be modified.

The arch under consideration is shown in Fig. 1. The axis is a transformed catenary coinciding with the conventionally assumed thrust line for dead load. The arch axis coordinates were computed as described in the excellent paper, "Design of Symmetrical Concrete Arches," by Charles S. Whitney, M. Am. Soc. C.E., published in Vol. 88 (1925), page 931 of TRANSACTIONS, with ratios of N = 0.225, m = 0.20, and g = 1.96.

The two models used in the investigation were made from celluloid having a thickness of 0.08 in., to a scale of 1 in. = 8 ft. The widths of the rib, deck, and spandrel columns were made proportional to the cube roots of the respective moments of inertia, which were assumed equal to $\frac{bd^3}{12}$. In computing the moment of inertia of the deck slab, the curbs and curtain walls were taken into account, and one-half the deck was assumed to be tributary to each arch rib.



CELLULOID MODEL OF HIGH-DECK STRUCTURE
Deformeter Gages in Place

The high degree of internal statical indetermination should be noted in passing. The deck with its columns forms a rigid frame, the supports of which (the arch rib) settle, spread, and rotate. In the case of the high-deck arch without expansion joints, the deck system alone presents a problem which, in the general case, involves 48 unknowns. These may be conveniently thought of

as horizontal forces, vertical forces, and moments acting at the extremities of the spandrel columns where they join the arch rib. It is hardly necessary to point out that these forces depend on: (1) the loads on the deck, (2) the relative stiffness of the deck and columns, (3) the movements of the arch rib, and (4) the temperature changes. It will be seen that most of these factors are interdependent if complete continuity exists, and furthermore that they influence the external abutment reactions. The problem is thus seen to lie in the field of mechanical rather than mathematical analysis.

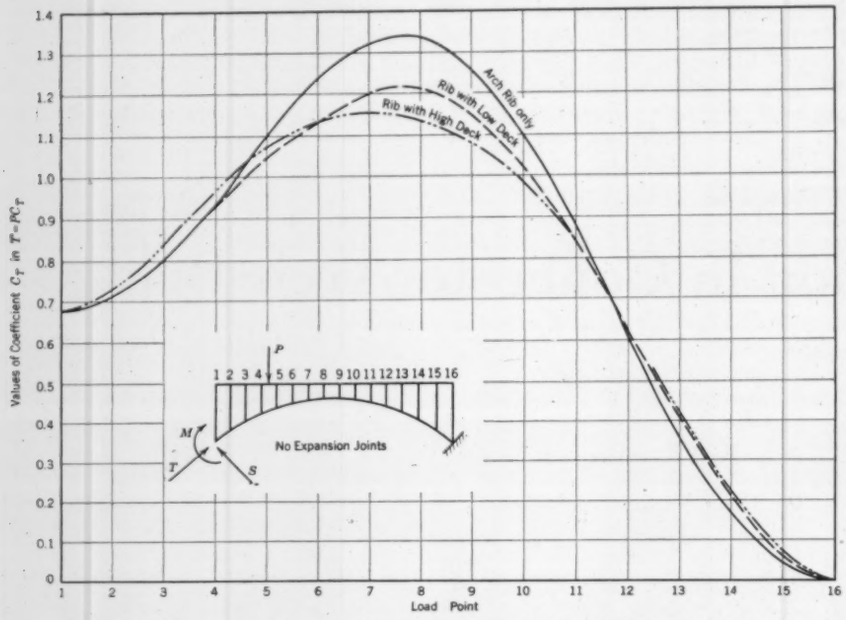


FIG. 2. INFLUENCE LINES FOR AXIAL THRUST, T, AT SPRINGING LINE
Effect of Integral Deck Action Shown

As a check on the technic used and the general handling of the mechanical method, a model of the unbraced rib was made and the mechanically obtained influence lines for thrust, shear, and moment at the springing line were compared with the mathematically obtained influence lines for the same functions. The ordinates for the last-mentioned method were taken from Mr. Whitney's paper, already mentioned. The agreement was very close, particularly in the case of thrust and shear. The two sets of influence lines for these functions were almost indistinguishable when plotted on the same diagram.

In the case of the influence lines for moment, the agreement, though fair, was not so close. The reason for this is perhaps not difficult to find. In producing influence lines for thrust or shear it is only necessary to produce displacements parallel to the lines of action of these functions, and such displacements may be made with a comparatively high degree of precision. In the case of an influence line for axial bending moment, however, it is essential to produce a truly axial rotation, and this is difficult to accomplish. If the center of rotation is displaced even a small amount from the true arch axis, discrepancies of appreciable amounts may easily occur.

Obviously, the models were very sensitive to temperature changes. As the control of temperature within the limits necessary is impractical in office work, I used a method of observation (which has doubtless been used by others) that eliminates the effect of the slow temperature "swings" occurring in most rooms. The object was to reduce to a minimum the time that elapses between the initial and final settings of the microscopes in any set of observations. The procedure adopted was to set the cross wires of the microscopes, read the micrometer heads, change the plugs in the deformeter gages, and reset the cross wires to the new position of the targets. This was done as quickly as possible, rarely more than one minute being required for the three microscopes. The second micrometer readings could then be taken at leisure. The process was repeated until all the targets had been observed. At the same time the temperature of the room was kept as uniform as possible. No direct sunlight and no draughts were permitted to reach the model. The fact that sets of readings could be duplicated at different temperatures combined with the very close checks afforded by statics on some of the results leads to the feeling that this system of observation virtually eliminated temperature effects.

In the case of the low-deck arch, in order to produce the various crown influence lines, the model was cut completely through at the crown. In the case of the high-deck arch, the rib only was cut, the deck remaining intact. Owing to the rigidity of the short spandrel columns adjacent to the crown in the high-deck model, it was found impossible to insert the large-sized thrust plugs. Therefore small-sized plugs were used in conjunction with "normal" plugs, thus halving the movement apart of the cut sections of the rib. The calibration factors were modified accordingly.

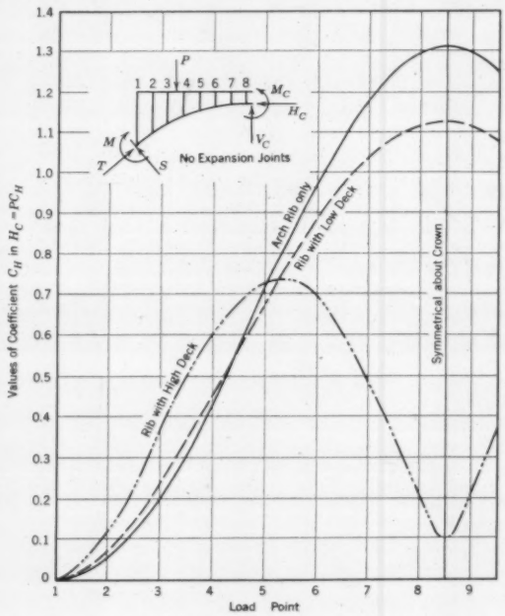


FIG. 4. INFLUENCE LINES FOR CROWN THRUST, H_c
Spandrel Columns Affect High-Deck Structure

INFLUENCE LINES COMPARED

Influence lines were constructed with each model. At the springing line the influence line for axial thrust, T, is shown in Fig. 2 and that for axial bending moment, M, is given in Fig. 3. At the crown, the horizontal thrust, H_c, is shown in Fig. 4, and the axial bending moment, M_c in Fig. 5. Influence lines for transverse shear at the springing line and for vertical shear at the crown are omitted because, in general, they do not affect the rib design.

In interpreting the influence lines plotted in these figures, some of which are unfamiliar in shape, particularly those for thrust and moment at the crown of the high-deck arch, it should be remembered that all influence lines are merely displaced load lines (as represented in this case by the line of the targets) due to some definite displacement to which the structure has been subjected. As a specific example, consider the influence line for H_c for the rib with high deck shown in Fig. 4. This line was obtained by forcing apart the cut sections of the arch rib between Columns 8 and 9 a unit distance without permitting any relative vertical movement or rotation. Actually, the movement used was about 0.018 in. and the resulting movements of the targets multiplied accordingly. The large effect of the continuous deck and spandrel columns is strikingly exhibited by comparison with the other two influence lines on the diagram. The influence lines for moment in the crown, M_c in Fig. 5, show in similar fashion the very considerable effect of the continuous deck on the value of this function.

DEAD-LOAD VALUES SUMMARIZED

A summary of the effect of the deck on the dead-load functions is given in Table I. The dead load in each case was that computed for the low-deck design, as this was the loading used in obtaining the shape of the arch axis. As in all the other tables, the conventional values are given in the column headed "rib only" for purposes of comparison. The expansion joints referred to are two in number and are located at the one-third points in the span.

In computing the values of the dead-load functions, no correction was make for the fact that the arch rib is a distributed load. All loads were assumed to be concentrated at the panel points. This explains in part the existence of the dead-load bending moments recorded in the column headed "rib only."

It will be noted from Table I that, while conventional analysis shows the dead-load pressure line to lie $3\frac{1}{2}$ in. above the arch axis at the springing line and $0\frac{3}{4}$ in. above it at the crown, the "true" position—and the word is used with a knowledge of its limitations—of the pressure line is very different. The low-deck pressure line is lowered at the springing line and raised at the crown. The high-deck pressure line is lowered at the crown and at the springing line. The very large crown moments in the low-deck arch should be noticed. In this case, of course, the deck slab is available to assist the rib in resisting these greatly increased moments. It is evident that the effect of expansion joints in the deck is very noticeable in all cases.

DECK ACTION AT THE CROWN

The horizontal thrust at the crown is greatly reduced by the action of the deck, especially in the case of the high-deck arch without expansion joints. It should be realized that this reduction in crown thrust implies that the deck at the crown is carrying a comparatively large thrust, which must be transferred to the arch rib through the action of the spandrel columns. In fact, a section cutting deck and rib at the crown will show by statics the existence, in general, of thrust, shear, and moment in the deck itself quite apart from that caused by the direct action of the loads.

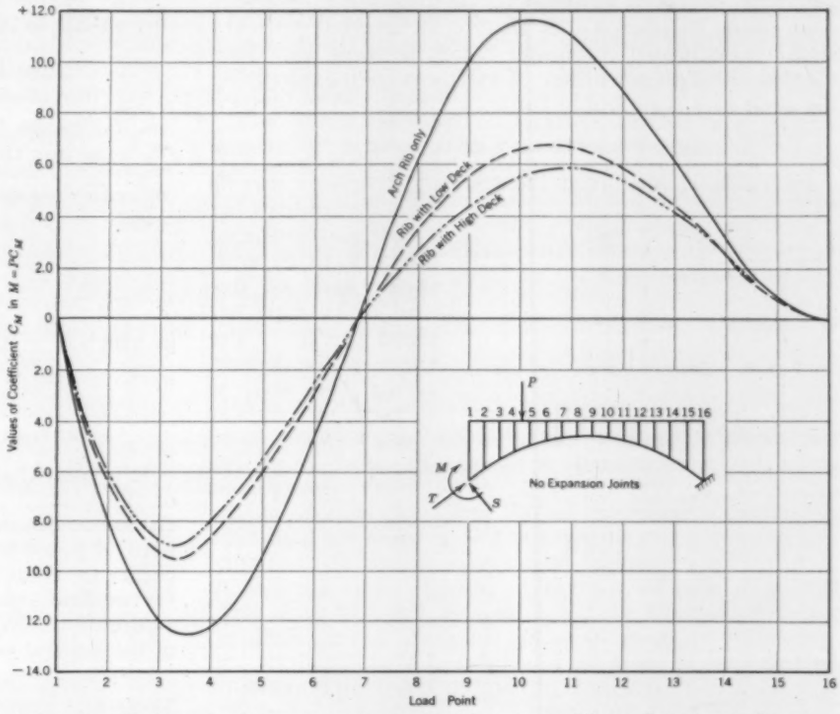


FIG. 3. INFLUENCE LINES FOR BENDING MOMENTS, M, AT SPRINGING LINE
Deck Action Is Clearly Shown

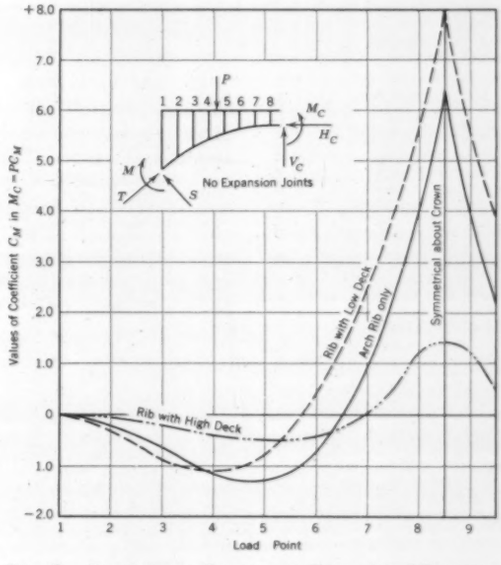


FIG. 5. INFLUENCE LINES FOR BENDING MOMENT, M_c, AT THE CROWN
High-Deck Structure Considerably Affected

DECK ACTS AS RIGID FRAME

It is very simple to visualize the disturbance of the pressure line caused by deck participation. Consider the transfer of load from the deck to the rib. In the conventional analysis all loads are considered to be applied vertically at the panel points. Actually, the deck is a rigid frame on yielding supports. Loads on the deck cause both vertical and horizontal forces as well as moments to be applied to the arch rib at each panel point. The pressure line will contain a sharp saw-tooth break beneath each spandrel column, and the magnitude of the break will be a measure of the moment

in the spandrel column. The new, irregular pressure line will of course still satisfy the condition that $\int \frac{Mds}{EI} = 0$, providing no abutment rotation has taken place.

The displacement of the dead-load pressure line from the location to which conventional thought has relegated it has been emphasized because some designers seem prone to assume that there is an intrinsic property about transformed catenaries which in some way fixes the dead-load pressure line. Extreme refinement in fixing the arch axis is probably futile.

DECK REDUCES LIVE-LOAD VALUES

In Table II are given the resulting live-load thrusts and moments at crown and springing line due to an arbitrarily assumed live load of 10 kips per panel per rib. The effect of the deck in aiding the arch is clearly shown. All functions save maximum moments at the crown of the low-deck arch are smaller than those given by conventional analysis. In most cases the difference is very marked. The most conspicuous reduction, amounting to 75 per cent, occurs in the maximum positive moment at the crown of the high-deck arch. The maximum negative moment at the same section is also very greatly reduced. The increase in positive moment at the crown of the low-deck arch, amounting to from 70 to 80 per cent, is very striking. In this case it must be remembered that the deck and arch rib are integral and the combined section is available to resist forces at the crown.

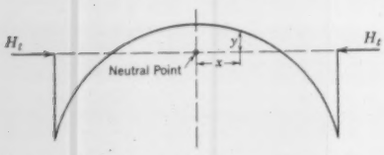


FIG. 6. TEMPERATURE THRUST

A substantial reduction in H_c, amounting to 33 per cent, is effected by deck participation in the high-deck arch. This reduction, as could have been foretold, is greatly reduced by the introduction of expansion joints. The effect of the deck on the values of the thrusts at the springing line is small.

TABLE I. STRESSES DUE TO DEAD LOAD ON VARIOUS TYPES OF ARCH, FOR ONE RIB

Thrust in Kips; Moments in Kip-Feet; Eccentricities in Inches. Positive Eccentricity Denotes Pressure Line Above Arch Axis.

FUNCTION	RIB ONLY	LOW DECK		HIGH DECK	
		Without Expansion Joints	With Expansion Joints	Without Expansion Joints	With Expansion Joints
T	562.5	546.9	548.5	544.8	553.6
M	+163.9	−169.7	−256.7	−222.4	−208.2
Eccentricity of T	+3.5	−3.7	−5.6	−4.9	−4.5
H_c	400.7	377.6	382.5	287.6	355.1
M_c	+23.2	+354.9	+272.2	−53.9	−36.8
Eccentricity of H_c	+0.7	+11.3	+8.6	−2.3	−1.2

CHARACTER OF TEMPERATURE THRUSTS AND MOMENTS

The magnitude of the temperature thrust in fixed arches, all else being equal, depends on the stiffness of the arch. The external reactions due to temperature can best be thought of as two oppositely directed forces (horizontal in cases of symmetry) applied to the arch through the neutral point. The actual abutment reactions due to temperature of course consist of a thrust and a couple applied at each abutment, of such magnitudes that they form the statical equivalent of the simpler, idealized forces previously referred to and shown in Fig. 6. The resulting bending moments caused in the unbraced rib can then be readily visualized as being proportional to the intercepts between the line of action of the temperature thrust and the axis of the arch. Of course the neutral point is located at the center of gravity of the $\frac{ds}{EI}$ values. The value of the temperature thrust is expressed by the equation:

$$H_t = \frac{\text{Change in span due to temperature if arch were free to expand}}{\text{Change in span due to a unit horizontal force acting through neutral point}}$$

or, in the language of calculus, neglecting rib shortening:

$$H_t = \frac{\alpha t l}{\int y^2 \frac{ds}{EI}} \quad \ldots\ldots\ldots\ldots\ldots\ldots [1]$$

in which α = thermal coefficient
t = change in temperature
l = span of arch

METHODS OF LOCATING NEUTRAL POINT

It is clear that any factors affecting either the position of the neutral point or the magnitude of H_t will affect the moments in the rib. The location ascribed to the neutral point by conventional analysis is very different from its actual location. Considering the rib alone, the neutral point may be located either directly or by summation. When the deck is considered, the position of the neutral point is best determined by experiment.

TABLE II. RIB STRESSES FOR ONE RIB DUE TO LIVE LOAD OF 10 KIPS PER PANEL PER RIB

All Thrusts Are in Kips, and All Bending Moments in Kip-Feet

FUNCTION	RIB ONLY	LOW DECK		HIGH DECK	
		Without Expansion Joints	With Expansion Joints	Without Expansion Joints	With Expansion Joints
T	125.4	120.8	121.1	119.8	121.9
$+M$	590.6	358.7	441.3	314.5	421.3
$-M$	460.8	334.0	436.7	308.0	410.5
H_c	96.7	90.2	91.4	65.0	81.0
$+M_c$	99.6	170.4	181.1	25.0	25.0
$-M_c$	82.9	62.0	88.6	33.0	30.3

It may be shown that the neutral point is that point through which the application of any force, suitably directed, causes movement in the same direction as the applied force. Forces applied along the principal axes possess this property. In cases of symmetry, of course, the principal axes are horizontal and vertical, and it follows that a horizontal force applied to the arch through its neutral point will cause this point to move in a horizontal direction only. This is equivalent to a change of span of the arch without rotation or vertical movement of either abutment.

From this conclusion an experimental method of locating the neutral point was devised. It is known that, in cases of symmetry the neutral point must lie on the vertical line through the crown of the arch. It remains only to locate its position on this vertical line. One abutment of the model was firmly clamped to a drawing board, and a rigid bracket made of sheet brass was clamped to the other abutment, which was left free to move. The model was carefully supported on ball bearings resting on plate glass, in the usual manner, to reduce all friction. A truly horizontal

force, obtained by a weight attached to a thread that passed over a pulley on the edge of the drawing board, was applied to the bracket. A microscope, with its cross hair horizontal, was centered over a target on the free end of the arch, and the point of application of the horizontal force on the bracket was very carefully adjusted until the movement of the free end of the arch was observed in the microscope to be horizontal. By definition, the line of action of the applied force then passed through the neutral point. A photograph gives an idea of the apparatus.

POSITION OF NEUTRAL POINT DETERMINED

As a check on the accuracy of this method, the position of the neutral point was determined experimentally, using a celluloid model of the unbraced rib. The theoretical position for this case was then calculated. The two results agreed within 2 per cent. The apparatus was very sensitive. The movements of the free end of the model, viewed in the field of the microscope as the line of action of the horizontal force was changed, were most interesting. No difficulty was experienced in determining when the line of action of the force passed through the neutral point, for a difference of a few hundredths of an inch in the position of the line of action of the force was sufficient to cause the movement of the free end of the model to deviate markedly from the horizontal.

TABLE III. COMPARISON OF TEMPERATURE EFFECTS

Changes in Span Lengths of Models Are Due to a Force of 100 Grams Acting Horizontally Through the Neutral Points

TYPE OF STRUCTURE	CHANGE IN SPAN IN DIVISIONS OF MICROMETER	DISTANCE OF NEUTRAL POINT FROM CROWN, IN FEET	RELATIVE VALUES OF TEMPERATURE THRUST, H_t	RELATIVE VALUES OF TEMPERATURE MOMENT AT SPRINGING LINE	RELATIVE VALUES OF TEMPERATURE MOMENT AT CROWN
Rib only	94	6.55	1.00	1.00	1.00
Low deck:					
Without expansion joints	64	9.5	1.47	1.28	2.13
With expansion joints	69	7.6	1.36	1.30	1.58
High deck:					
Without expansion joints	49	12.7	1.92	1.42	3.73
With expansion joints	57	8.5	1.65	1.51	2.15

The relative magnitudes of H_t were determined for the low-deck and the high-deck arches by proportion. This was done by determining experimentally the movement at the free end of the celluloid model of the unbraced rib, due to a known horizontal force acting through the neutral point, using the same apparatus as before. Similar movements were measured in the case of the other two models. From Equation 1 it was known that the various temperature thrusts would be inversely proportional to such movements. Considering the temperature thrust of the unbraced rib to be unity, the relative values of the other two thrusts were calculated.

As was anticipated, both the position of the neutral point and the values of the temperature thrusts were found to differ markedly from those obtained by the conventional method. The results of the experiment are summarized in Table III, in which the temperature effects are compared.

It will be seen from this table that the position of the neutral point is greatly influenced by the deck, especially when no expansion joints are used. The high deck with no expansion joints causes the neutral point to drop more than 6 ft. from its conventionally ascribed position. The effect of expansion joints in the deck is very marked, the variation in the position of the neutral point being about one-third as great as when no expansion joints are used.

The values of the temperature thrusts are greatly increased by integral deck action, the relative values varying from 1.36 to 1.92 times the conventional value. The effect of expansion joints is to reduce the increased thrust due to temperature, though even with such joints there is still a considerable increase in the thrust.

With such large changes in the thrust and its line of action, the temperature moments are greatly modified, the moment at the crown naturally suffering the greatest increase. From the designers' standpoint, of course, the very cause of these increased temperature effects, that is, the stiffening effect of the deck, is also the means by which the arch is enabled better to resist them.

CONCLUSIONS SUMMARIZED

As a result of these experiments, the following conclusions seem warranted:

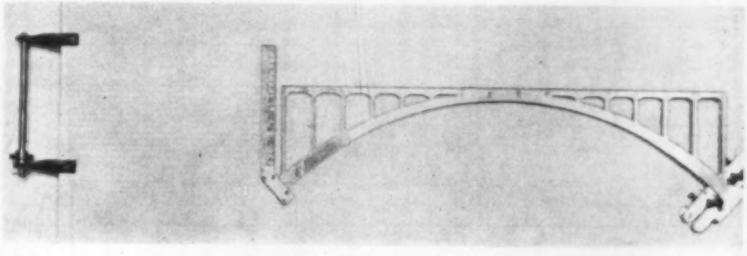
1. The true position of the dead-load pressure line is considerably different from that conventionally assumed. Appreciable dead-load moments exist, even in an arch whose axis coincides with the conventional dead-load thrust line. Extreme refinement in fixing the arch axis is probably futile.

2. The live-load thrusts, moments, and shears at both crown and springing line are reduced—in certain cases very much so—by deck action, with the exception of the moments at the crown of the low-deck arch. As has long been realized, the deck aids the arch ribs. How harmful this assisting rôle may be to the deck is undetermined.

3. The position of the temperature thrust line is very greatly changed. In all cases the effect of deck action is to lower the temperature thrust line, a condition that could have been qualitatively foretold. The temperature thrust is greatly increased, as was to be expected.

4. The effect of expansion joints is very marked, especially on the position of the temperature thrust line, and also on the magnitude of the thrust itself.

It is realized that the recorded results may prove of little quantitative aid to designers, but it was not for this purpose that the experiments were undertaken. In the broad field of structural design many factors must be approximated. There are two reasons for introducing such approximations, expediency and ignorance. Too often the former is made a cloak for the latter. That the more complex features of deck participation must be ignored in ordinary design is fairly obvious, but approximations based on a clear idea of their significance must be viewed in a very different light from those based on ignorance of the factors involved.



APPARATUS USED TO LOCATE THE NEUTRAL POINT
Celluloid Model of Low-Deck Structure

Systematic Sequences in Annual Stream Flow

Predictions Based on Cyclic Variations Have Been Verified

By A. Streiff
Member American Society of Civil Engineers
Vice-President, Fargo Engineering Company, Jackson, Mich.

Forecasts of some sort, while necessary in all engineering projects, are of particular importance in connection with the construction and financing of a hydro-electric plant. As Mr. Streiff points out, if such a plant is put in operation at the beginning of a descending cycle in run-off, it may fail financially even though the preliminary forecasts were correctly calculated according to probability based on available past records. He gives definite references to show that, by means of the Horton cycle and the Wolf sun-spot numbers, he has been able to predict run-off accurately at least two years in advance.

PRIOR to 1926 it was generally accepted in the discussions published in the Proceedings and Transactions of the Society that annual stream flow represents a fortuitous sequence. According to this viewpoint, the only possible method of analysis would be via the theory of probabilities. Since certain flows would have a certain probability of occurrence, hydraulic works would have to be adjusted to this condition.

Actually, application of the probability theory to stream flow presents several difficulties. In order to enable application of that theory, two conditions must be fulfilled: the number of known cases must be very large, and the series must be wholly free from systematic sequences. Neither of these requirements is fulfilled in the case of stream flow.

In stream flow, as in nearly all other engineering problems, predictions of some sort are necessary. Hence the method of probability was used for stream flow, as discussed in several papers published in the Transactions of the Society, among which may be mentioned the following: "Storage to Be Provided in Impounding Reservoirs for Municipal Water Supply," by the late Allen Hazen, M. Am. Soc. C.E., in Transactions, Vol. 77 (1914), page 1539; "Flood Flows," by Weston E. Fuller, M. Am. Soc. C.E., in Transactions, Vol. 77 (1914), page 564; "The Probable Variations in Yearly Run-Off as Determined from a Study of California Streams," by L. Standish Hall, Jun. Am. Soc. C.E. (now Assoc. M.), in Transactions, Vol. 84 (1921), page 191; and "Theoretical Frequency Curves and Their Application to Engineering Problems," by H. Alden Foster, Assoc. M. Am. Soc. C.E. (now M.), in Transactions, Vol. 87, page 142.

Fortuity Methods Unsatisfactory

The insufficiency of the fortuity methods described in these papers has been often felt. Hydro-electric plants, for instance, require a certain amount of average annual flow in order to yield sufficient returns on the capital invested. If the frequency curve derived from past records of flow is used as a basis for the financial set-up, and if, after completion of the undertaking, the flow should be below normal for a number of years, the interest on the bonds might not be earned and financial failure might result. Such cases have occurred and do occur in spite of the fact that the returns were correctly calculated by means of the frequency curve based on available past records. Average values may furnish ample returns, but the grouping may be fatal.

Might not more accurate results be obtained by following other methods of investigation? Are these periods of drought really haphazard phenomena? Are they unpredictable? Can the next five years be years of high flow or low flow with equal likelihood, as would be the case according to the probability theory?

Starting some fifteen years ago, these questions were seriously investigated. It was found that there was a large amount of literature in existence on the subject of climatic oscillations. However, from these scientific studies no definite knowledge had resulted that could be applied to engineering problems for several reasons. For example, if measured by the thermometer or barometer, the amplitude of the systematic climatic changes that occur is extremely small compared with the large and sudden fluctuations that take place from day to day. Hence meteorologists, interested in forecasting and recording weather changes, attached no importance to these climatic sequences and the conclusion that they were unimportant was taken over by the science of hydrology as a matter of course, although the fields of the two sciences are totally different.

Meteorology deals with momentary values, while hydrology deals with cumulative quantities. Systematic changes may be small if measured by thermometer or barometer, but they are of prime importance when recorded by current meter or surveying instrument. For example, the changes in rainfall are amplified in run-off. This is illustrated by the fact that in Michigan a 30 per cent increase in rainfall doubles the run-off.

A further reason why the science of climate was not applied to engineering is that there was no method of analysis that engineers could use in seeking the cyclic elements in run-off records. By 1926, however, enough material had been gathered to warrant my presenta-

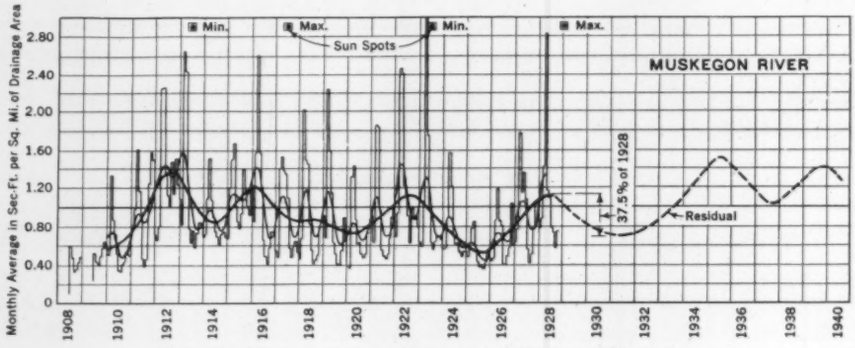


Fig. 1. Flow of the Muskegon River, Michigan
Note Agreement of Sun-Spot Numbers with Peaks of Flow

tion of the idea that run-off varies in cycles in the discussion of the following papers: "Straight Line Plotting of Skew Frequency Data," by R. D. Goodrich, M. Am. Soc. C.E., in TRANSACTIONS, Vol. 91 (1927), discussed on page 46; "Storage Required for the Regulation of Stream Flow," by C. E. Sudler, M. Am. Soc. C.E., in TRANSACTIONS, Vol. 91 (1927), discussed on page 681; and "Probability of Flood Flows," by F. G. Switzer, Assoc. M. Am. Soc. C.E., in PROCEEDINGS for April 1927, discussed in the May 1927 issue, page 1012. In discussing these papers, instead of treating records of annual stream flow as a fortuitous sequence, I proposed that they be regarded as containing systematic sequences, the finding of which would aid in the solution of engineering problems.

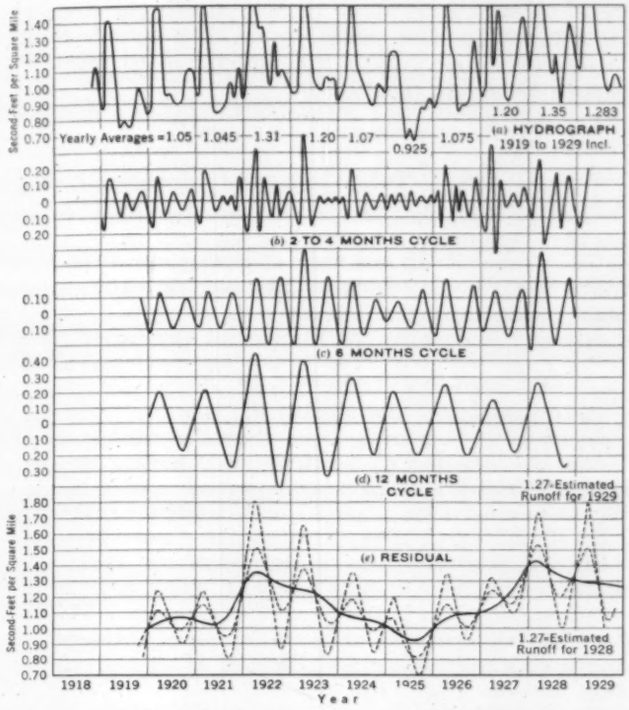

Second Feet per Square Mile
Yearly Averages = 1.05 1.045 1.31 1.20 1.07 0.925 1.075 1.20 1.35 1.283
(a) HYDROGRAPH 1919 to 1929 Incl.
(b) 2 TO 4 MONTHS CYCLE
(c) 6 MONTHS CYCLE
(d) 12 MONTHS CYCLE
1.27-Estimated Runoff for 1929
(e) RESIDUAL
1.27-Estimated Runoff for 1928
1918 1919 1920 1921 1922 1923 1924 1925 1926 1927 1928 1929
Year

FIG. 2. STUDY OF FLOW, MANISTEE RIVER, 1919–1929, INCLUSIVE

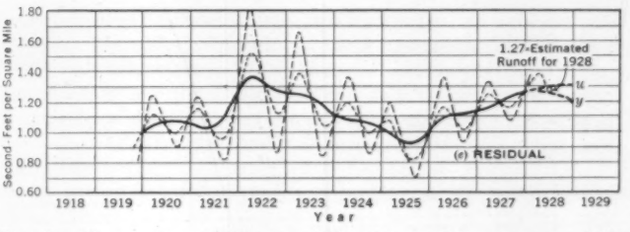


FIG. 3. FLOW OF THE MANISTEE RIVER AS ESTIMATED IN 1928
From Page 98, *U.S. Monthly Weather Review* for March 1928

ANALYTICAL THEORY DISCUSSED

In a series of papers I further discussed the theory needed to analyze stream flow into its cyclic elements. The July 1926 number of the *Monthly Weather Review*, issued by the U.S. Weather Bureau in Washington, contains, as far as is known, the first published analysis of flow records into elementary cycles.

Regarding stream flow as a systematic sequence implies the possibility of continuing the sequence into the future, qualitatively and quantitatively, for the estimate of future stream-flow records. These views necessarily represented such a radical departure from prevailing opinion that many hydrologists doubted their validity.

In the discussions previously listed, the inevitable retort from those adhering to the principle of fortuity was: "How can systematic sequences, even if they exist, be found, and the time of occurrence and amount of their maxima and minima determined?" These logical questions suggest an extensive and ambitious program. But a modest beginning can be made by settling the following fundamental question: "Can it be demonstrated that systematic sequences in annual stream flow actually exist and can they be determined quantitatively as a function of time?" This could be done by publishing estimates a long time prior to the date of occurrence. It was necessary to wait six years to gather the material for a definite answer to this question because six years is the approximate length of the so-called Horton cycle of stream flow.

This cycle was discovered by Robert E. Horton, M. Am. Soc. C.E., and described by him in the U.S. Geological Survey water-supply paper No. 30, in 1899, as applied to the watershed of the Kalamazoo River. He estimated that the next minimum would occur in 1901, or two years after the forecast was published. His estimate was exactly realized, as may be seen from the *Monthly Weather Review* of October 1929.

HORTON CYCLE AND WOLF NUMBERS CORRELATED

The Horton cycle has recurred ten times since 1875 and five times since the publication of its discovery. I found a strong correlation between it and the Wolf (sun-spot) numbers, and therefore wrote in PROCEEDINGS for November 1926, page 1845: "For example, in southern Michigan, increased run-off is expected for the next two years, in accordance with the strong correlation with the Wolf numbers." From Fig. 1, giving the flow of the Muskegon River in Michigan, it may be seen that this estimate was verified two years later. But since in 1928 the Horton cycle was in the ascending phase, further demonstration of its course near its top and in the descending phase was needed, as well as a quantitative determination. Hence, in the *Monthly Weather Review* of March 1928, a description of the analysis of the Manistee River was given. In my paper entitled "Notes on Estimating Run-Off" an estimate was made of the flow of that river for the year 1928. The Horton cycle was then near its culmination. The estimate proved 6 per cent too low. The actual flow is given in Fig. 2, which shows the analysis of flow for that river, and should be compared with Fig. 3, reproduced from page 98 of the *Monthly Weather Review* for March 1928. This may be regarded as a demonstration of the possible limits obtainable in a quantitative estimate.

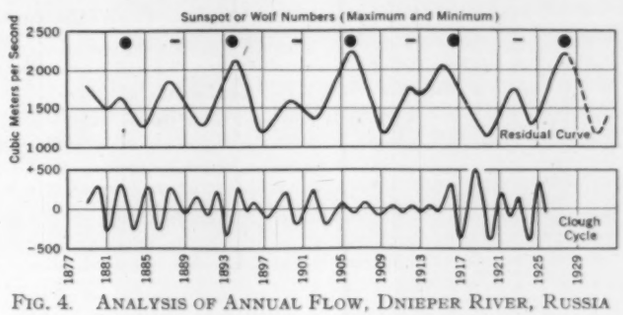

Sunspot or Wolf Numbers (Maximum and Minimum)
Cubic Meters per Second
Residual Curve
Clough Cycle
1877 1881 1885 1889 1893 1897 1901 1905 1909 1913 1917 1921 1925 1929

FIG. 4. ANALYSIS OF ANNUAL FLOW, DNIEPER RIVER, RUSSIA
First Published in *U.S. Monthly Weather Review*, January 1931

Later, in the periodical *Power*, for April 1929, another paper by me appeared, entitled "Periodicity of Stream Flow and Power," in which the accompanying Fig. 1 was first published. This gives the flow of the Muskegon River as it was known up to that time (end of 1928) in a full line. The continuation of flow as estimated was presented in a dotted line. The Horton cycle, if it actually existed, had then to enter on its descending phase. It may be seen that a minimum was expected to occur in 1931. The year 1930 is also shown to be dry. The drought of 1930 is only too well remembered. In this region run-off diminished still further in 1931, although the rainfall was greater and better distributed. This 1931 minimum occurred exactly as presaged in April 1929. In Fig. 1 it is shown that the predicted run-off in 1931 was 37.5 per cent lower than that in 1928.

CYCLE CHECKED WITH POWER OUTPUT

The graph records the flow of the river at the Croton Dam of the Consumers Power Company, where the whole flow is utilized, with the exception of the flood discharges, which are habitually small owing to the vast ground storage of the glacial soil of the Southern Peninsula of Michigan. The output for the year 1928 was 47,310,500 kw-hr. For the year 1931 the output was 18,393,000 kw-hr. less, or 38.8 per cent of the output of 1928. The systematic nature of the flow of the Muskegon River made it possible to determine two years in advance not only the fact that there would be a minimum in 1931, but also its numerical value to within 1.3 per cent.

That this cycle applies to the whole of the Southern Peninsula was also demonstrated. The output of all the hydro-electric plants of the Consumers Power Company during the year 1928 was 465,000,000 kw-hr. That in 1931 was 330,000,000 kw-hr., or 135,000,000 kw-hr. less than that of 1928. The deficiency had been estimated at 160,000,000 kw-hr., as published in the *Monthly Weather Review* for October 1929. The error in the prediction was 25 million in 465 million, or 5.4 per cent.

Thus it is seen that the ascending as well as the descending cycle can be accurately estimated two years in advance and within comparatively narrow limits.

In Fig. 4, first published in the *Monthly Weather Review* for January 1931, is given an analysis of the annual flow of the Dnieper River, Russia. Again the correlation with the Wolf numbers is strongly in evidence. It may be seen that in this record the Wolf 11-year cycle of sun spots is of greater amplitude than the Horton cycle. The record covers four periods of the Wolf cycle; the change from minimum to maximum was for these four repetitions:

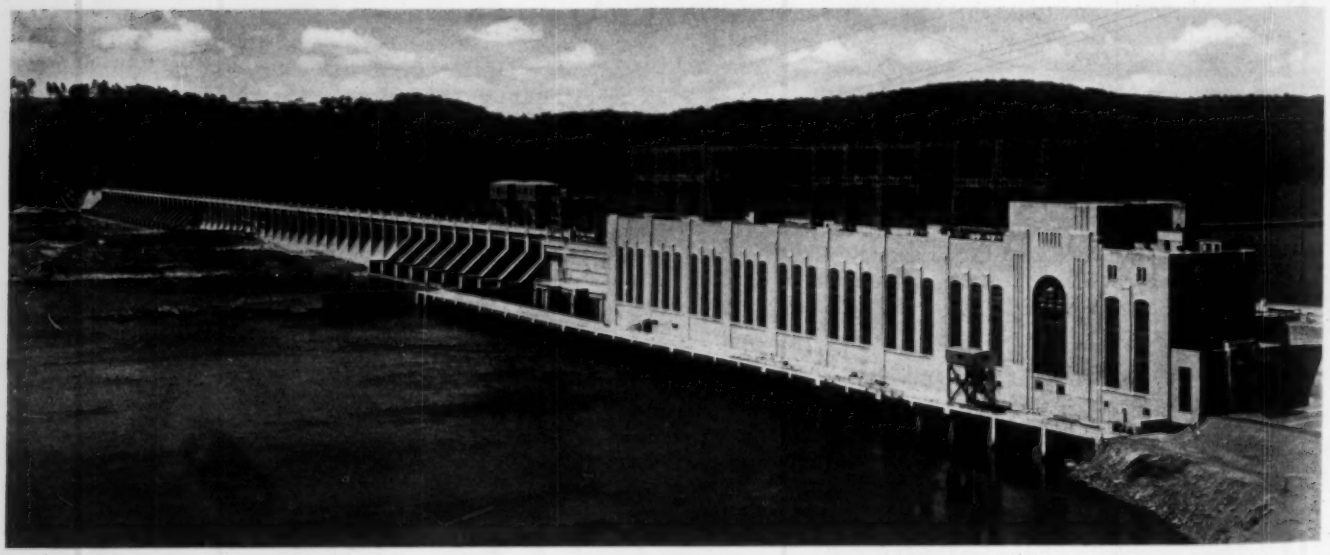
PERIOD	ANNUAL FLOW
First	31,500 sec-ft.
Second	36,700 sec-ft.
Third	29,750 sec-ft.
Fourth	36,700 sec-ft.
Average	33,663 sec-ft.

The average is no less than 42.4 per cent of the maximum flow. It may be seen that, although the climatic change caused by the Wolf cycle is very small, perhaps 1 deg. cent. or less, its effect on stream flow is very large.

CYCLES IN NORTH AMERICA AND RUSSIA AGREE

A comparison of Fig. 4 with Fig. 1 reveals a striking coincidence. It may be seen that the minima in the Great Lakes region of North America and in the great plains of Russia strikingly agree as to time of occurrence. These minima took place in both regions in the years 1909–1910; 1913–1914; 1919–1920; and 1924–1925. Although at this writing no record of the Dnieper for 1931 is available, it may safely be said that the flow was low, as it was in the Great Lakes region. The data for the Dnieper River were obtained through the courtesy of Mlle. Maretzky, Chief of Hydrological Division, Moscow, U.S.S.R.

Apparently the current views on fortuity of annual stream flow need revision. Systematic sequences are strongly evident on the great continental plains, but are less regular in mountainous and coastal regions. But even in those areas, nature, though infinitely complicated, will permit the separation of systematic sequences from the tangled mass of available data. In time it will be possible to predict the characteristic trends of stream flow with an accuracy not possible at present.



SAFE HARBOR HYDRO-ELECTRIC PLANT BUILT BY PENNSYLVANIA WATER AND POWER COMPANY ON THE SUSQUEHANNA RIVER
Completed in December 1931 After a Construction Period of Twenty Months. Six 42,500-hp. Kaplan-Type Turbines, with Automatically Adjusted Runner Blades, to Deliver 800,000,000 Kw-Hr. per Year

Difficult Subway Construction in Sand

Extensions Into Brooklyn Demand Special Treatment in Passing Beneath an Existing Subway

By JOHN R. MONAGHAN, M. AM. SOC. C.E.
CHIEF ENGINEER, THE DEL BALSO CONSTRUCTION CORPORATION

In collaboration with JOHN J. FITZGERALD, JR.
ASSISTANT CHIEF ENGINEER, THE DEL BALSO CONSTRUCTION CORPORATION

and HOWARD F. PECKWORTH, ASSOC. M. AM. SOC. C.E.
CIVIL ENGINEER, SLATTERY-DAINO COMPANY, INC.

A SUBWAY system is not unlike a magnified roller coaster. In following under the streets, the tunnels and tracks turn and twist, duck under rivers, dodge bad foundation conditions or pass under them, rise and fall to meet controlling grades, and respectfully avoid underground aqueducts. Where the system provides four or more tracks, the relative positions of the local and the express tracks change, sometimes rising one pair above the other to meet special station conditions or weaving from side to side as branch-line tracks enter or leave. Subway construction always involves the problem of underpinning buildings and of transferring heavy concentrations of load to new bearings. This article describes some of the difficulties encountered on a half-mile contract for the 55-mile independent city-owned subway system at a point in Brooklyn where it passes under an existing subway structure already occupying most of the street.

As familiar as engineers are with the construction of subways in the crowded parts of cities, there are now and then unusual sections which contain a concentration of difficulties. When a stretch of subway less than half a mile in length goes under seven buildings varying in height up to eight stories, under one subway and immediately over two others, under an elevated railway and alongside of, and below, the spread foundations on sand of a 15-story building, there is a concentration of construction problems such as few other engineering projects can offer. Such a situation was found on Route 107, Section 6, of New York City's new subway under Schermerhorn Street and Lafayette Avenue, in the Borough of Brooklyn.

PRELIMINARY OPERATIONS

Route 107, Section 6, is a part of New York's new city-owned and operated subway of which an eight-mile section along Eighth Avenue, Manhattan, was put into operation in September of this year. Extending under Schermerhorn Street, Brooklyn, from Bond Street to Flatbush Avenue, this route crosses under the I. R. T. (Interborough Rapid Transit Company) Subway and extends up Lafayette Avenue to Fulton Street. The contract required that the streets be kept open to traffic and that the surface-railway and subsurface structures be maintained. As the subway structure itself occupied the full width of the street, it was necessary to excavate from building line to building line to depths varying from 21 to 60 ft. To comply with the contract and employ modern methods of doing the work, a system of decking and street support, shown in Fig. 1, was designed to permit the operation of steam shovels below the street surface, with entrances and exits to allow the free movement of the trucks loaded by the shovels.

EXCAVATION IN THREE SECTIONS

The excavation was divided into three sections, each of which was undertaken independently of the others. East of the I. R. T. Subway a shaft 17 by 31 ft. was excavated to subgrade and a truck elevator was installed in it. To provide access to the work at the west end of the contract, a ramp 12 ft. wide and 130 ft. long was built. While the sinking of the truck-hoist shaft was in progress, excavation east and west of it proceeded to a depth of 4 ft. Open-web girders with a depth of 32 in. were installed longitudinally and the street was decked as shown in Fig. 1. The use of the open-web girders made it possible to install decking and supports in sections, as required by the contract, which provided that only 100 ft. on one side of the street should be excavated in advance of the decking.

When the truck-hoist shaft reached subgrade, an excavation west of it was made by a clam-shell bucket operated from the street. Into this excavation a steam shovel was lowered and operated in conjunction with the clam-shell excavator. This method was followed

Ample Space for Shovel and Trucks

First Steam Shovel Ever Used in a Subway Cut

STEEL DECK GIRDERS SUPPORTED ON 12 BY 12-IN. POSTS EXTENDING TO SUBGRADE

until subgrade was reached and a space cleared large enough for a truck to be lowered on the elevator and run into the cut, where it could be loaded directly by the shovel. This was probably the first time a steam shovel was used in a subway cut. As the excavation proceeded, the longitudinal decking girders were temporarily supported on posts. As soon as there was sufficient room, a section of transverse girder was placed and supported on posts set in pits excavated to subgrade.

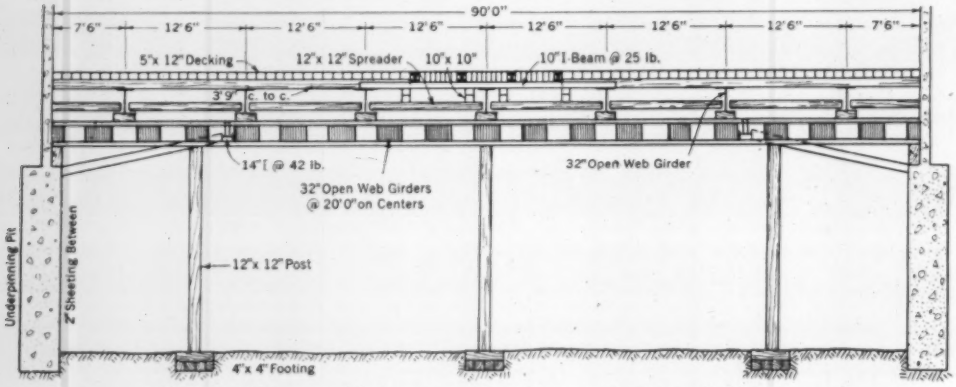
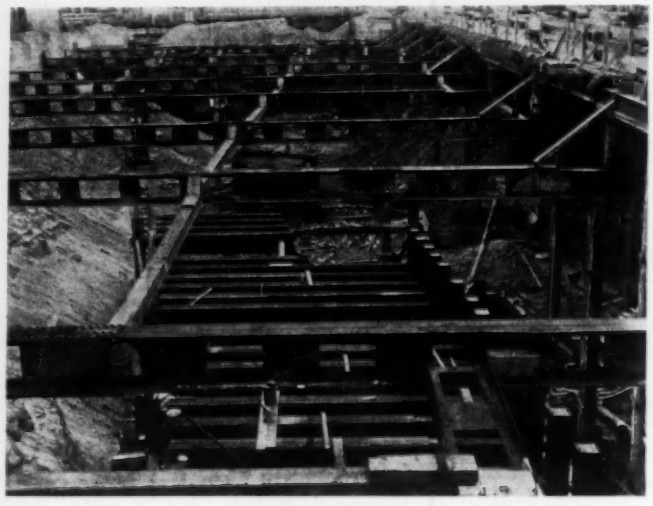


FIG. 1. TYPICAL DECKING ON LAFAYETTE AVENUE, BROOKLYN
Street Traffic Maintained During Construction

COMPLICATED INTERWEAVING OF TRACKS

In this section of the subway the tracks, having just left the transfer station at Court and Schermerhorn streets, are realigned in order to continue on their routes along Fulton Street (the main line) and Lafayette Avenue (the crosstown line). This realignment requires two center-line curves, 272 and 211 ft. in length; 25 circular track curves; and 25 transition track curves, varying in length from 28 to 257 ft. As the section is only 1,930 ft. long, it is evident that there is a constant shift in the relative positions of the tracks and a continual change in the structural cross section. At no point is the grade less than 1 per cent, or more than $3^1/_2$ per cent. Grade changes are accomplished by means of nine vertical curves.

Starting at the west end of the section, the crosstown tracks are $5^1/_2$ ft. lower than, and sandwiched between, the two eastbound and the two westbound tracks of the main line. The structure at this point is 133 ft. wide and 39 ft. deep, abutting the buildings on the north and extending 73 ft. beyond the south building line of Schermerhorn Street under property acquired by the city. The eastbound crosstown tracks drop while the main tracks rise. At the southwest corner of Nevins Street the structure undercuts the Junior League and Y. W. C. A. buildings. When the crosstown tracks have reached a grade completely below the main tracks, the former swing to the north while the latter draw together and start to drop.



PLACING SUBWAY STEEL IN AN OPEN CUT
Open-Web Girders Used to Brace the Side Banks

Shortly after undercutting the Court of Domestic Relations building the subway structure attains its greatest depth, 60 ft. below the curb, where a sump and pump room have been established. When the crosstown tracks have passed completely under the main tracks, they rise and meet the descending main line, which passes under the I. R. T. Subway at Flatbush Avenue. After passing under the I. R. T. Subway at Flatbush Avenue, the tracks veer to the north before they straighten out along Lafayette Avenue and undercut the building at 65 Flatbush Avenue, the City Savings Bank, and Nos. 9 and 11 Lafayette Avenue, all on the north side of the street.

One of the methods most frequently used when building a new subway under an old one is to reinforce the old subway by building up plate girders between the tracks. These large girders are tied into the tracks in such a way that the old subway is made to act like a bridge over the place where the new subway is to be built. Thus the load of the subway trains is carried across the new subway and the timber posts underneath act as secondary to the girders in carrying the load. When loaded with heavy subway trains such a bridge over a construction tunnel will have a certain deflection, amounting underground to a settlement. Once there is settlement it must remain because the cost of wedging or jacking the subway back to its original position would be excessive even if it were possible. The settlement by this method is normally between 2 and 3 in.

The erection of plate girders between the tracks of the old subway is slow, costly, and dangerous work and the attendant settlement cannot be avoided. For these reasons it was decided to confine all underpinning operations at the Flatbush Avenue crossing to the outside of the old subway.

ECONOMY ACHIEVED

When underpinning work is carried on inside an old subway it is necessary to change the existing lighting and signal apparatus, an expensive operation, usually costing around $100,000. By confining all operations to the outside of the subway this sum was saved to the city. The complicated situation at Flatbush Avenue is indicated in Fig. 2.

The first step, then, was to sink a shaft down the side of the old subway and obtain a working chamber at its base. An old abandoned subway track facilitated this operation. From the abandoned track a drift was extended under the old subway through the brown, sandy

gravel on which it rests. The gravel material varied from a fine sand to a coarse gravel with a few clay seams and pockets. Occasional "nigger-head" boulders increased the difficulty of advancing the paling boards. Bed blocks of 6 by 12-in. timbers were laid for a floor in the drift, and the sides were supported by 2-in. sheeting. Posts 8 by 8 in. and 5 ft. tall were set on channels on the floor of the drift. On the tops of the posts were put 2 by 6-in. short screw jacks, which supported 6-in., 20-lb. I-beams at their centers. The I-beams directly supported the under side of the old subway. These beams were 3 ft. 4 in. long and coped on the ends so that the last one put in could be bolted to the one preceding.

The first drift was pushed forward in steps so that at any one time the unsupported roof area was not larger than 4 by 6 ft. When the first drift had advanced a distance of 20 ft. under the subway, similar drifts were started on each side of the first one. This progress was continued until seven drifts had been completed from one side of the subway to the other.

Girders were built up on the floor of every other drift, as may be seen in Fig. 3. These were made of 8 by 8 by 1-in. angles 14 ft. $11\frac{1}{2}$ in. long; 36 by $0\frac{3}{4}$-in. web plates 7 ft. 5 in long; and 8 by $0\frac{3}{4}$-in. chord splices 7 ft. 5 in. long. They were bolted together by $1\frac{1}{2}$ by 6-in. bolts spaced 5 in. from center to center. The pieces were carried into the drifts and bolted together in places where it would have been utterly impossible to get a rolled beam.

LOAD OF ROOF TRANSFERRED TO GIRDERS

When the girders had been completely erected, the load of the roof was transferred to them from the 8 by 8-in. posts. This was done by placing 12-in., 55-lb. I-beams 3 ft. 4 in. from center to center under the 6-in. roof beams, at their centers and at right angles to them. The I-beams were held in place above the 36-in. girders by means of short 12-in., 25-lb. I-beam posts. On each side of these posts were placed short 8 by 8-in. posts with 2 by 6-in. jacks on them. Steel wedges were used to keep the 25-lb. I-beams securely in place while the jacks were being tightened. Every 24 hours the wedges were driven in as far as possible and the jacks were tightened. The first three or four times this was done there was always slack to be taken up. After that it was nearly impossible to budge them. As soon as the load of the roof was taken on these shorter posts above the 36-in. girders, the 5-ft. timber posts were removed.

Pits on 15-ft. centers were sunk to subgrade under the main girders, alternate pits being sunk at one time so that each girder was always supported by earth for a distance of 30 ft. or by pits for a distance of 15 ft. from center to center. In the bottom of each pit, four piles 16 in. in outside diameter and 5 ft. long were driven to a depth of 6 ft. below subgrade. The pits were then filled with concrete and a 2-ft. mat of concrete was poured in two sections so that the piles could be tested in pairs.

On each pair of piles were placed three 12 by 12-in. posts 6 ft. long. Above the posts but underneath the 36-in. girders were placed two 8-in., 24-lb. I-beams bolted together. On the center post and underneath the channels was placed a hydraulic jack. On the two outside posts and under the I-beams were placed 2 by 6-in. screw jacks. A load of 80 tons was then placed on the hydraulic jack and the settlement of the base was noted. It generally amounted to about $0\frac{1}{8}$ in. but varied from very slight to $0\frac{3}{4}$ in. This load of 80 tons was applied continuously until there was no settlement in a period of 5 min. At the end of that time the screw jacks on the posts at each side of the hydraulic jack were screwed up until they could be tightened no further. The load on the hydraulic jack was then carefully released, the jack removed, and a 12 by 12-in. block fitted into its place and tightened with steel wedges driven to refusal. This same procedure was followed under all the supports of the 36-in. girders, the purpose being to take up settlement at their bases before it could affect the supported structure.

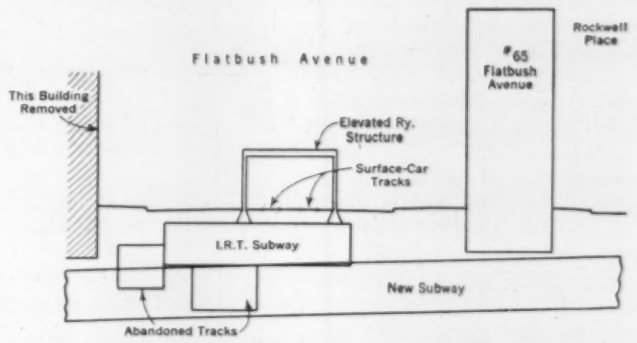
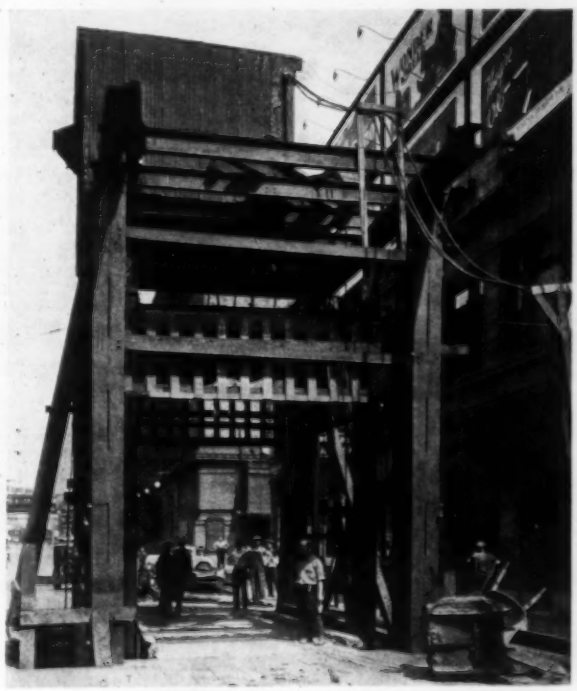


FIG. 2. SECTION SHOWING COMPLICATIONS AT FLATBUSH AVENUE
The New Subway Supports an Old Subway Structure, the Surface-Car Tracks, the Elevated Structure, and Numerous Buildings

The side walls of the new subway were put in at the same time that the pits were sunk. This was done by putting the pits next to each other and concreting them solidly. The steel posts, used instead of 12 by 12-in. posts, and the 36-in. girder were concreted in as part of the side wall.



TRUCK ELEVATOR RAISES LOADED VEHICLES FROM SUBWAY TO STREET

PERMANENT STEEL PLACED

After the first four girders had been supported and one side wall put in, the remaining excavation along the wall was completed to subgrade. Portable belt conveyors were used to facilitate this excavation. While the side next to the wall was being excavated to subgrade, more drifts were pushed in and two more 36-in. girders were built up. As soon as the excavation had advanced far

enough, the permanent steel for the first track next to the side wall was erected and the load of the old subway was transferred to its final position on this steel. When the steel in the first track had been set and had taken the load, the 36-in. girders below it were removed and used in new drifts. Thus all the operations were in progress at the same time—drifting, erection of girders, transference of roof load to the girders from the 8 by 8-in. posts, sinking of pits, excavation down to subgrade, erection of steel, transference of load to the permanent steel, and removal of the underpinning girders.

LOOKING INTO A DRIFT UNDER THE I. R. T. SUBWAY
36-In. Built-Up Girder in Place on the Right

OBSTRUCTION ENCOUNTERED

The drifting operation was slightly delayed by encountering another abandoned track, which cut diagonally across the line of the new subway. The concrete of this structure was drilled and blasted with small charges and then the same procedure followed as in earth. Over two thousand yards of concrete were thus removed.

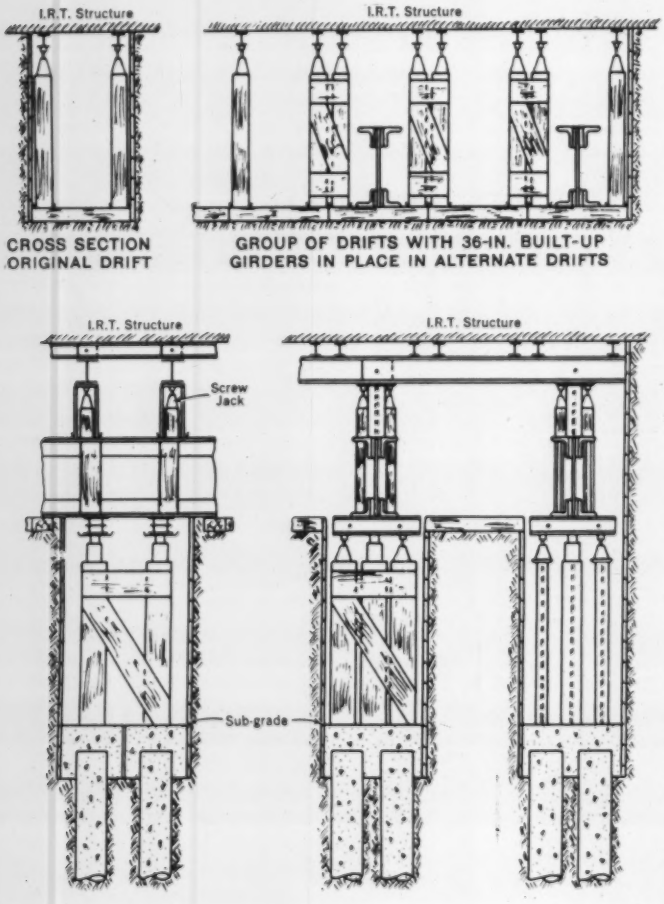


FIG. 3. UNDERPINNING SEQUENCE USED UNDER OLD SUBWAY
Below, Subway Load Transferred to 36-In. Girders

The steel of the underpinning was so placed that the permanent steel fitted in between with a minimum amount of obstruction. Where there was interference, the underpinning steel was carefully burned away, the load being held by the permanent steel on one side and by the underpinning steel on the other. The actual settlement of the street surface, as measured on the four elevated railway columns that rested on the I. R. T. structure above, was negligible.

UNDERPINNING A BUILDING

Of the buildings under which the subway went, one of the most interesting was a six-story loft building more or less triangular in shape at 65 Flatbush Avenue. The subway cut under one corner of the triangle so that five of the building piers, or about one-third of the building, eventually rested on the roof of the new subway and two-thirds remained undisturbed on the original footings. The building projected out over the subway 38 ft. 6 in. on one side and 25 ft. on the other.

The cellar floor of this building was dug up and the grillage beams at the base of the building columns were exposed. A trench was dug between the footings so that two 24-in. built-up girders could be placed along each side of the building in this trench and tied into the small grillage beams. One girder was put along each side of each row of columns. Each pair of girders was tied together with $0^{3}/_{4}$-in. tie rods, and the whole concreted in. The footings affected by the subway construction were thus tied together by these steel and concrete girders in such a way that pits could be put under them at any place, the girders being used to spread the building load while the pits were being dug. These pits were 4 by 5 ft. They were placed one on each side of each building column and were sunk to 2 ft. below subgrade. In the bottom of each pit were placed two pair of piles, each 5 ft. long and driven to 6 ft. below subgrade. To spread the load, 4-in. grillage beams were placed over the piles and then encased in concrete up to subgrade, as shown in Fig. 4.

SETTLEMENT TAKEN UP BY JACKS

Each pair of piles supported three vertical columns so placed that the permanent steel did not interfere with them. The center column was a 12 by 12-in. timber post supporting a 100-ton hydraulic jack reacting against jacking beams on the under side of the steel and concrete underpinning girder. The two columns on each side of the timber column were 12-in., 28-lb. I-beams. On their tops were placed small 1-in. steel plates supporting short, 2-in. screw jacks, which in turn were under the jacking beams under the underpinning girders. A load of 75 tons was then exerted by the hydraulic jack and continued until in any 5-min. period there was no settlement. At the end of this time the screw jacks on each side were tightened by means of a

bar until they could be tightened no further. The hydraulic jack was then removed and a short piece of 12 by 12-in. timber, butt-end to the load, was forced into that space and wedged to refusal with steel wedges, the screw jacks on each side being kept tight while this was being done. The 2-in. screw jacks were then encased in cement grout to ensure against any movement.

SUBWAY TAKES LOAD

As soon as the load of the building had been carried to subgrade by means of these pits and columns, the earth between them was excavated by hand, loaded on belt conveyors, and dumped into buckets, which were lifted to the street by a crane. When the excavation had reached subgrade, the permanent footings of the subway columns were set; the permanent steel of the subway was erected; and the load of the building was taken on this permanent steel by means of steel supports and steel wedges, which were placed between the permanent steel and the under side of the underpinning girder. The subway steel was then concreted in; the underpinning columns were burned away; and the process was completed. The load of this six-story building was transferred from its original footings to the top of a new subway built below its footings without the slightest settlement.

PERMANENT STEEL IN PLACE AND CONCRETE ROOF TAKING THE LOAD
36-In. Girder and Supporting Posts Ready to Be Dismantled

SURVEYS MADE BY CONTRACTOR

On former subway work the city furnished the contractor with a complete and detailed field layout of the structure, so that the construction foreman worked directly with the field engineers and inspectors of the Board of Transportation. On this contract an entirely different method was pursued. From profiles and line data furnished by the city, the contractor computed base of rail and subgrades, net lines, steel elevations, and column and track bench offsets. His results were checked against the corresponding computations of the Board of Transportation. The excavation was laid out by the contractor's engineers and the structure built according to his surveys. The Board checked the depth of underpinning pits before they were concreted, and usually the steel was checked before it was riveted. The actual checking of the structure was not done until after construction was completed. All the work incidental to underpinning layouts, location of decking supports, shafts, ramps, gas by-pass towers, the transference of lines into the excavation, the recalculation of offsets from base line or center to working lines in the excavation, the details of form work, and the restoration of subsurface structures, sidewalks, curbs, and street surfaces, was done independently by the contractor, who was entirely responsible for it.

The surveying in connection with the underpinning required extreme accuracy and exceptional resourcefulness so that the underpinning columns would avoid the structural steel and keep the retaining walls exactly along the net line. The lines were brought into the cellars of buildings through any available opening—a window, ash hoist, vault light, or coal chute—and then transferred around partitions and into the underpinning pits. The setting of the structural steel columns amid the maze of underpinning timber, especially when the column lines were on curves, was a painstaking and tedious job. The column locations had to be recomputed as each working line was blocked and a new one established.

This work was executed by the Del Balso Construction Corporation under contract for the Board of Transportation of the City of New York. The consulting engineer on this project was J. C. Meem, M. Am. Soc. C.E.

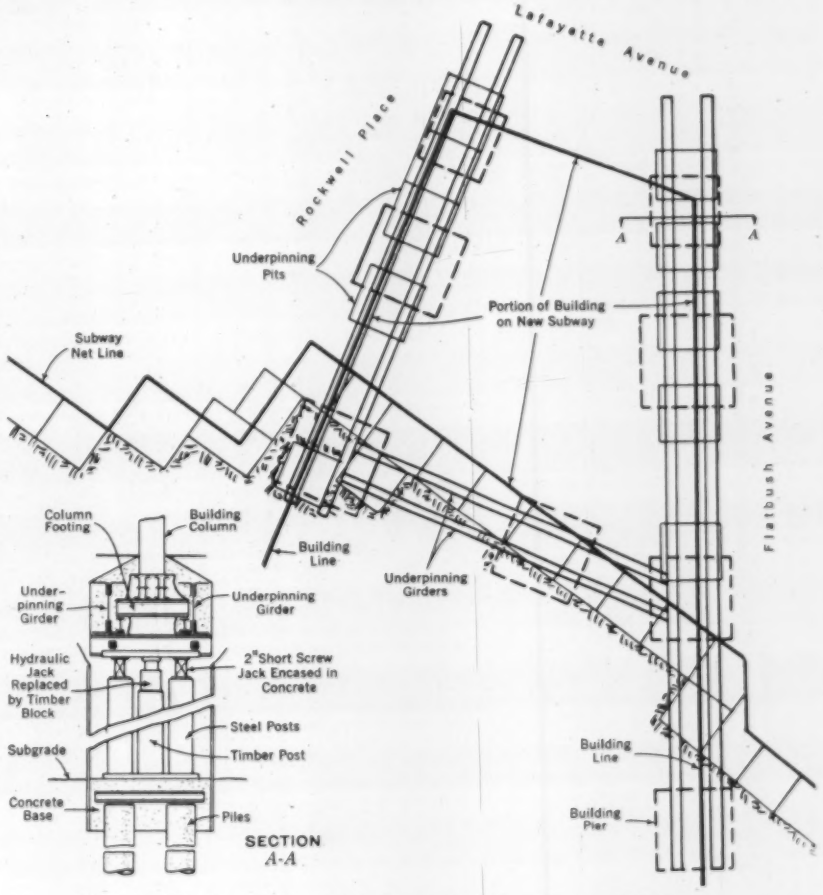


FIG. 4. PLAN AND SECTION, SHOWING UNDERPINNING METHOD USED AT 65 FLATBUSH AVENUE, BROOKLYN

A Study of Motor Transport

Its Application to the Movement of Freight and Passengers

By O. W. KOCHTITZKY, JR.

MEMBER OF THE STUDENT CHAPTER OF THE UNIVERSITY OF NORTH CAROLINA, CHAPEL HILL, N.C.

FREIGHT cars weigh four times as much as the average less-than-carload freight hauled in them. It therefore costs more to haul the cars than to haul the freight. Trucks, however, can haul two pounds of freight with one pound of truck. In this article, for which Mr. Kochtitzky was awarded one of the two prizes given by the North Carolina Section for the best paper presented in competition from the two Student Chapters of the state, is presented the viewpoint that on short hauls the motor vehicle is the most convenient and economical means of transportation for both freight and passengers. It is an interesting and useful product of the Society's Student Chapter activities.

SINCE the function of transport is the transfer of people and things from one part of the earth's surface to another, in a minimum time and at a minimum cost, the efficiency of transportation methods has a direct and significant bearing on the progress of civilization and the development of the wealth of a country. The chief use of motor transport is not so much to furnish an independent means of transportation as it is to act as a complementary and supplementary system in providing outlets to isolated communities and feeders for trunk-line railroads. Hence, motor transportation is not to be considered as an epoch-making invention initiating a new era, but rather as an instrument in perfecting an era already partly developed.

The first motor truck was a converted automobile with a crudely constructed body. Now there are trucks carrying as much as 5 tons of freight at a high speed, and heavy-duty types which, with a trailer, sometimes carry as much as 50 tons. In any line of business a scientifically operated fleet of trucks pays dividends to the owner either in dollars and cents or in efficient and economical distribution of goods. Also, motor service eliminates the additional handling necessary in hauling to and from the railroad.

Representative of the main classifications of motor transportation are the materials transported, which may be listed, in the order of their importance to humanity, as follows: foods, of which milk, bakery products, live stock, produce, vegetables, and fruit will be considered; general merchandise; retail delivery packages; oil and gasoline; and railway express matter. In addition to the commercial uses of motor trucks, they are employed by public utilities, municipalities, and state highways for a number of special kinds of haulage.

TRANSPORTATION OF FOOD

The gradual crowding out of the dairy farm from densely populated areas has necessitated some speedy method of delivering milk. It may be carried by railway, but this does not supply facilities for rapid distribution, and the horse-drawn vehicle is not adequate in large cities. Some of the advantages of motor transport are that it reduces the number of handlings, the expense, and the time required for delivery.

A recent survey of the baking industry revealed that 65 per cent of the delivery service was done by gasoline trucks. These trucks were found to give daily service 50 per cent more efficient than electric trucks, and 200 per cent greater than horse-drawn vehicles doing the same work. In general, it has been found that motor trucks that are in good condition and attractive in appearance swell the volume of business.

In the transportation of live stock the motor truck has the advantage that it affords minimum shrinkage, swift delivery, ability to take advantage of favorable market prices, less cost for feeding and watering stock while in transit, and ability to make shipments of either a few or a large number at one time. Consequently motor transportation is rapidly gaining in favor for this purpose. There are many other applications of the motor truck to the live-stock industry, such as the use of roll-off bodies to carry and dump food for hogs.

For perishable commodities such as vegetables and fruits, the motor truck can be used very effectively in cooperation with the railroad to handle this produce between metropolitan rail terminals and suburban areas, thus effecting a great saving in time and preventing the large expense that would be entailed if the railway had to move its cars to these areas.

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NEITHER ROME NOR ATHENS

Truck Traffic Clamoring for Entrance to Manhattan Bridge, New York

President Hoover, who by virtue of his position as Food Administrator during the World War, became an authority on the subject, said: "Fifty per cent of our perishable foodstuffs never reach the consumer because the farms on which they are raised are too remote from the market at which they are sold."

The Bureau of Crop Estimates of the U.S. Department of Agriculture reported that in 1918 the cost of hauling in wagons from farms to shipping points averaged 30 cents per ton-mile for wheat, 33 cents for corn, and 48 cents for cotton as compared

with the corresponding costs of 15 cents, 15 cents, and 18 cents, when motor trucks were utilized. Thus, in addition to speeding up delivery, the use of trucks might cut in half the cost of hauling to the shipping point.

PACKING CHARGES REDUCED

Goods that are to be hauled in truck-load lots, in enclosed motor vehicles between points connected by good highways, require only sufficient packing to protect them from ordinary damage. Sometimes a paper cover or an excelsior pad is sufficient. Thus great savings result through elimination of the heavy packing needed for rail or water transportation, including not only the actual packing cost but also the transportation charges on the additional weight. On the other hand, less-than-truck-load lots must be carefully packed as protection against damage, loss, theft, and handling while they are being transferred between connecting

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FIVE TONS OF MISSOURI HAY HEADED FOR THE OZARKS
Hauling from West Plains to Gainsville, Mo., 45 Miles

lines. In such cases the packing costs are nearly as great as for rail or water transportation.

The majority of motor truck traffic moves less than 30 miles; comparatively little, less than 10 per cent of it, moves over 100 miles. It has been shown by actual studies that in specific instances long haulage by motor is more economical than that by rail. The General Superintendent of the Hartman Furniture and Carpet Company, H. Lorenzen, has shown that motor transportation of the company's freight from Detroit to Chicago is faster than express—the fastest rail service—and cheaper than freight—the cheapest rail service—provided a return load is secured. Generally, however, long hauls are unprofitable, whereas hauls under 45 miles are usually profitable. In many cases speed of delivery outweighs any considerations of extra cost incurred by motor transport.

TRUCKS ADAPTED TO MANY USES

Different types of bodies are available for use on trucks in practically every line of industry. There are armored bodies for valuables, steel bodies for cigarettes, huge vans for furniture, and lift-off or roll-off bodies for other uses. At a comparatively small additional cost, trailers can be attached to trucks, thus raising the total capacity by from 10 to 40 tons of load.

It is becoming almost essential that retail stores should maintain delivery service, largely because the modern woman does not like to carry packages. For short hauls, with frequent stops for house-to-house deliveries, the electric truck has proved most economical. Large stores in metropolitan centers often operate a fleet of trucks, sometimes numbering in the hundreds, and give daily delivery service within a 75-mile radius,

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HUGE TRUCKS AT WORK ON HOOVER DAM
At Left, 14-Cu. Yd. Body; At Right, 9-Cu. Yd. Body

in which case gasoline trucks are better. Also, many stores keep only samples for show purposes at the store and make delivery from suburban warehouses.

The United States is first among the nations in the production of automobiles and trucks; in 1928 over 24,490,000 units were registered. These must have fuel, so the production of gas and oil ranks fourth among our national industries, and a vast organization is needed to supply these products to the ultimate consumer. Over 38,000 trucks are used to haul bulk gasoline and oil from reservoir tanks to retail service stations.

Express companies must keep their terminals free from congestion; so motor vehicles are employed to make rapid deliveries. Some express companies also use motor transportation for long or heavy hauls, sometimes employing trailers.

Many utilities use trucks with specially constructed bodies, such as fire trucks, street cleaning units, police patrols, snow plows, and refuse collectors, trucks equipped for telephone-line construction or repair, and those carrying portable compressed-air drills. Another use of trucks is to carry mail, express, and baggage between airports and post offices. High-speed vehicles are needed for this purpose.

COORDINATION OF RAILROAD AND MOTOR TRUCK

Trucks may be used in cooperation with railroads, for example, to carry merchandise between the railroad and the shipper or receiver, and to shift freight within terminals or from a substation to the terminal. Railroad companies often charter motor vehicles or maintain their own. Generally, however, this handling is done by independent companies. By coordination of motor trucks with railroads several advantages are to be gained: accelerated movement of freight; lower rail rates; and direct, door-to-door service between the shipper and the consignee.

It is apparent that for comparatively short hauls the motor truck is the most economical means of transportation.

Today motor buses are public conveniences, even

necessities. The bus is the cheapest form of commercial travel in America, the average fare charged being approximately 25 per cent lower than that for any other commercial vehicle. Besides this saving in fare, the passenger also enjoys the convenience of being able to

© *Railway Age*

PENNSYLVANIA MOTOR COACH TERMINAL, NEW YORK
200 Passenger Buses Arrive and Leave Daily

enter or leave the bus at any desired point along its route.

On January 1, 1929, there were in operation in the United States over 92,000 buses, of which 41,000 were used for the carrying of school children. At that time the mileage on scheduled routes was 720,000 as compared with 250,000 for steam railroads. In 1928, buses carried about 1,800,000,000 passengers. So vast a system of transportation must have had an effect on the steam and electric railways; so it is not surprising that owing to the private automobile and the motor bus, passenger traffic on railroads has steadily declined since 1925.

Railways are now using buses to replace local train service, or as auxiliary to it; as feeder lines; to carry employees to and from shops; for train connection service between terminals, as in New York and Chicago; and for tours to summer resorts and in national parks. The operation cost per mile for a bus is between 25 and 30 cents and that for a local train is from $1.25 to $1.50, excluding fixed charges and road maintenance.

In 1928, interstate buses sold $1,450,000,000 passenger miles and carried 29,000,000 passengers. Now bus service may be had between practically every city and town in the country, and there are main express lines between all large cities. There are 23,300 companies operating buses, including independent operators as well as utilities and railroad companies. The Greyhound Lines and Yelloway Stages, consolidated, operate 110 different routes between the principal cities of the United States, from coast to coast, Lakes to Gulf, and border to border. This system has recently become allied with several of the largest railroad systems in the country.

Today the long-distance motor-bus companies are operating buses that have every convenience. There are Pullman-type coaches with sleeping quarters for 25 or 30 persons, dining service, lavatories, and smoking compartments. The Pullman buses have two decks, but the upper is telescoped into the lower so that the total height is not much greater than that of an ordinary bus.

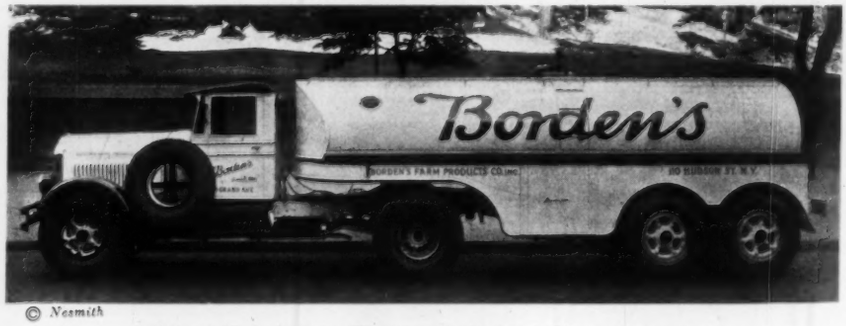
Practically every city transportation company in the country makes use of the motor bus, and some have adopted it to the exclusion of electric street cars. In most cases the cost per mile has been lowered by this means and the revenue consequently increased. Some of the advantages of the bus are: that it loads at the curb, thus protecting its patrons from danger due to traffic; it avoids the necessity of fixed routes and heavy investment in track and power equipment; and it permits operation on a flexible and easily changed schedule.

Obviously, buses and trucks are much heavier than smaller cars and consequently require stronger road surfaces. Therefore they should bear more of the burden of the road cost. The average-sized common-carrier motor truck pays $303 per annum, 15 times as much as a private automobile, and the common-carrier motor bus pays $520 per annum, or approximately 24 times as much as a private car, for which the average charge is $21.50. This does not include general taxes on gasoline. In the United States the regulation of motor trucks and buses is very lax, and passenger rates vary over a wide range.

In his book on *Motor Traffic Management*, G. Lloyd Wilson states:

> It is desirable from the standpoint of the motor truck operators, of the rail, water, and express carriers, and of the public, that uniform interstate jurisdiction be assured as soon as legislation fair to all concerned can be worked out as so to define more clearly the field of the motor in interstate commerce; to establish more definitely the correlation of the rail, water, and motor carriers; to eliminate dangerously destructive competition between the various transportation services; to eliminate irresponsible operators from the motor field; and to protect the shipping public from the wastes of unrestricted competitition.

It may be concluded that the motor bus is more economical to operate than the railroad and the fares



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MILK COLLECTING TRUCK—A RECENT DEVELOPMENT
Capacity 2,500 Gal.; Non-Corrosive and Non-Shatterable Lining of Alleghany Metal

are lower, but generally the time required between two points is greater in the case of the bus because of the numerous local stops.

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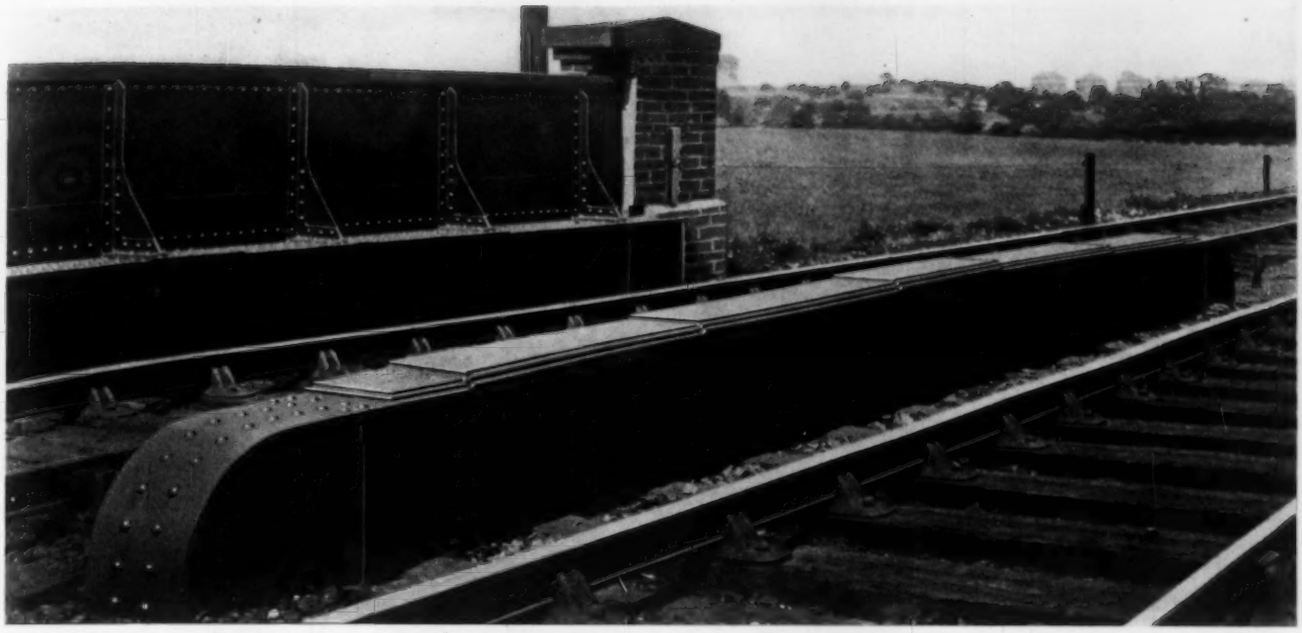


A Completed Girder, with Two Cover Plates Added

Strengthening Bridges by Welding

Application in England to Structures Subjected to Heavy Traffic Proves Satisfactory and Economical

By H. J. L. Bruff

Bridge Assistant, Northeastern Area, London and Northeastern Railway, London, England

STRENGTHENING of plate-girder spans to carry the increased weights of growing railroad traffic has been accomplished with apparent success in England by welding. In this article, prepared from a paper submitted in the Lincoln Electric Company's contest, Mr. Bruff describes the simple but effective method adopted for adding cover plates to one group of bridges and of welding new floor systems into another group. The original paper won a prize of $500 and ranked fifth in the contest, which was judged by the faculty of the Electrical Engineering Department of Ohio State University. Engineers will watch with interest the results of this use of structural welding for repair work.

ALTHOUGH the problem of weak bridges and heavy traffic was beginning to occupy the minds of bridge engineers in England before the War, the question was made acute by the demands of the War and the still greater demands of post-War commerce for greater loads carried at greater speeds. Of late years British bridge engineers have been faced in increasing measure not only with the necessity of renewing, or at best reconditioning, old and worn bridges, but also with the more perplexing problem of strengthening modern and physically sound bridges that are too weak for the added loads they are required to carry. In the case of old bridges that have economically fulfilled their purpose, the bridge engineer is prepared, though grudgingly, to replace them, but when he is confronted with a structure only part of whose useful life has expired, he rebels at the idea of renewal and tries, by traffic restrictions, to stave off as long as possible the evil day when "something" must be done.

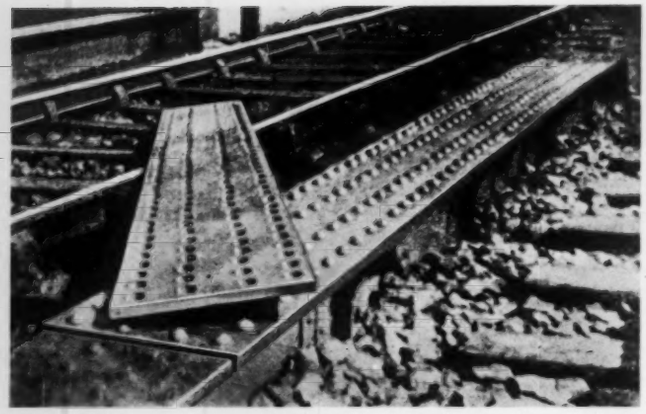
There are various possible solutions of the problem of what this "something" is to be. As a rule the amount of extra metal required is small, but the process of placing it where needed is very costly, and requires in many cases the temporary withdrawal of the structure from use.

For years the possibility of adding metal to existing bridges by means of electric welding has engaged my attention. Being assured that the process was sound and reliable and therefore offered a means of reducing heavy renewal costs, I placed the facts before my superior, John Miller, Engineer for the Northeastern Area of the London and Northeastern Railway Company, who saw the possibilities of the process. As a result, independent records were collected relative to the strength, soundness, and practical usefulness of the method for such purposes as structural iron and steel work, and rail conditioning.

As data became available, the results and conclusions were applied to actual bridge work, so that the experiment and its practical application have gone hand in hand from the very beginning. Any new problems that came up were investigated in the shop and laboratory before an attempt was made to solve them in the field.

The first bridges repaired were of the three-girder type, having side and central main girders with transverse trough floors. Usually it was the trough floor that proved to be weak, but in the case of five bridges it was discovered that the main girders were also deficient in strength.

Concerning the trough floors, it was found by repeated and careful strain-gage tests that the usual assumption as to the distribution of the loads over the floors was on the safe side, that is, less favorable than was actually the case. It was decided, therefore, that these floors did not need strengthening. There still remained, however, the five bridges with weak main girders. To meet the requirements of the Traffic Department would have meant their complete reconstruction at a total estimated cost of approximately $27,900 apart from any losses due to interference with traffic. While the best method of carrying out this work was being con-



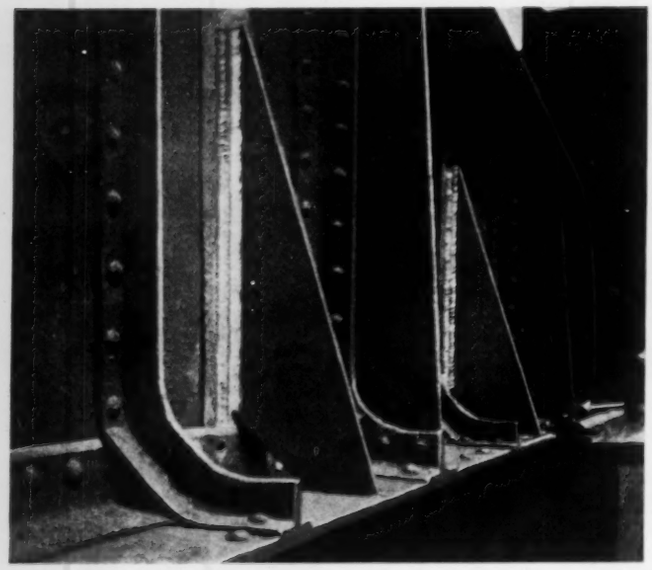
STRENGTHENING PLATE DRILLED TO HOUSE RIVET HEADS

sidered, I suggested as an alternative that they be strengthened by electric welding. As the preliminary test gave favorable results, it was decided to apply the method first to a bridge that was strong enough, and then, if the results of a strain-gage test justified its adoption, to use it on the five bridges in need of strengthening.

TEST STRUCTURE WELDED

The first, or test structure was a plain plate-girder bridge 2 ft. 0 in. deep over the flanges, which were 1 ft. 4 in. wide. In Fig. 1 are shown cross sections of the central and side girders, the hatched parts indicating the added flange material, which consisted first of a plate with $1\frac{1}{2}$-in. holes drilled to house the rivet heads of the old girders. One such plate is illustrated. As will be seen from Fig. 1, the top plates were narrower than the original flange plates, to facilitate placing of the weld along the edges of the new plate. For the same reason the bottom plates were made wider than the old flanges, thus eliminating overhead welding. On top of the rivet-housing plates a second set of plates, similarly differing in width from the first, were welded in like manner. The combined area of the two added plates was such as to bring the resulting stress down to that desired.

After these operations on the main girders were completed, three troughs of the floor were strengthened by welding plate strips to the tops and bottoms of the troughs, as indicated in Fig. 1. The welds were deposited in 6-in. lengths—the first on one side at the end of the trough, the second at the other end diagonally opposite the first, the third opposite the first, and the fourth opposite the second. This rotation was continued until the plate had been completely welded all around. When these troughs were tested the results were completely satisfactory.



WELDED FLOOR-PLATE SUPPORTS

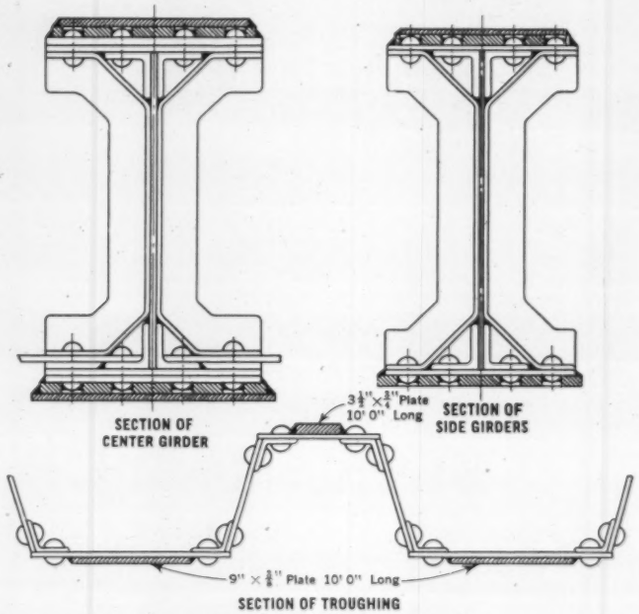


FIG. 1. METHOD OF STRENGTHENING A PLATE GIRDER BRIDGE
Cross Hatching Indicates New Material Added; Welds Are in Solid Black

This completed the work on the five bridges that required strengthening of the main girders. The experience gained indicated that the welds used were too large and heavy, and thereafter much lighter welds were laid down. The top flange of one of the bridges after it had been strengthened is shown in the illustration on the first page of this article.

When the work was completed it was found that the total cost of strengthening the five bridges came to $5,900. Since the alternative was their complete renewal at an estimated cost of $27,900, the saving was approximately 80 per cent.

OLD WROUGHT-IRON BRIDGES REPAIRED

Two wrought-iron plate-girder bridges erected in 1865 were next repaired. They stand close together and carry the railway over two public roads and an electric colliery railway. As they are on sharp curves and placed close to houses and streets on one side and a steep hill on the other, it was impracticable to renew them by building new bridges alongside and sliding them into position. It was decided, therefore, to resort to electric welding, partly on account of the difficulties of erecting new bridges, partly because it was anticipated that less interference with traffic would result, and finally because the previous experience with bridge strengthening by welding had indicated that a substantial saving would result.

The main girders were not highly stressed, and as their condition was fairly good except for deformation, it was decided to retain them but to renew the highly

stressed and badly corroded cross girders with a welded steel joist and plate deck floor. When the bridges were examined before preparing the working drawings, it was found that the main girders were badly deformed, both vertically and horizontally. To provide for drainage from the flat deck floor, it became necessary to measure up the old girders very carefully to determine the correct thicknesses of the packing under each end of the new cross girders, where they rested on the flange angles of the main girders and on the abutments. These new girders, which were steel beams with flange plates, were welded to the main girder webs. Because they butted up against the angles and flange cover plates, careful measurement of their length was required to secure good weld connections. The longer cross girders had plates welded to the flanges, those next to the top flanges of the joists being wider, so as to provide seatings for the deck plates.

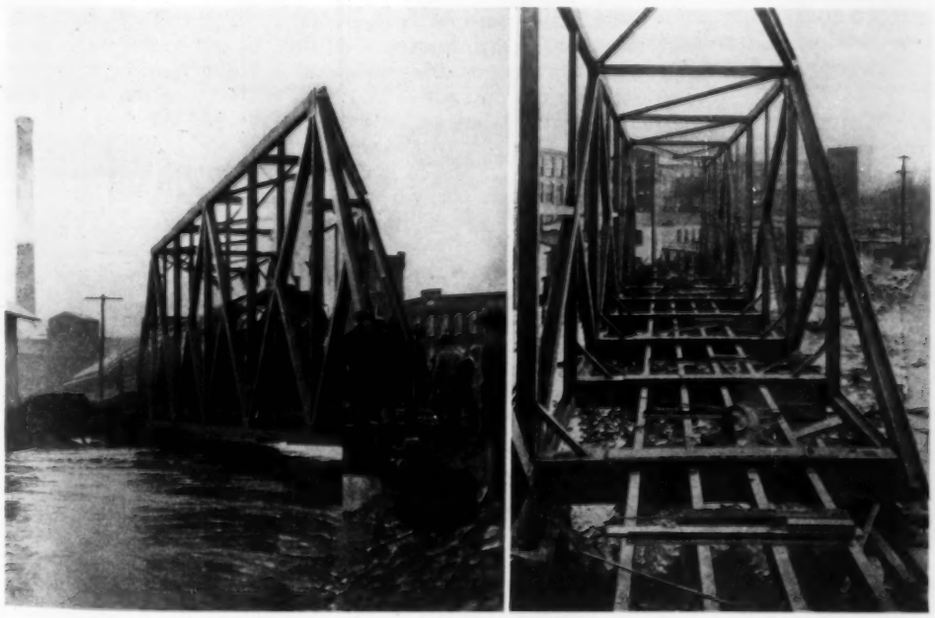
CORRODED EDGE OF GIRDER FLANGE BURNED AWAY AND WELDED PLATES ADDED
In Background, Welded Supports Under New Floor Beams

The stringers under the rails were also steel beams, the top flanges of which fitted between the cross-girder flanges. To avoid accumulation of error, lengths were allowed tolerances of only $0^1/_{16}$ in.

Owing to the heavy traffic, which on this road consisted of one train every 8 min. during daylight hours, and one every 5 min. during rush hours, it was important that as little interruption as possible should take place, and for this reason the floor members were welded together in the railway company's shops at Gateshead in sections consisting of two cross girders with intervening rail bearers and deck plates. Before commencing operations, a temporary timbered track was built, so constructed that it was possible to remove sections of it above the part to be renewed. The old cross girders were then burned off, the new units placed in position, the timber track sections replaced, and the units welded to the main girders. In spite of the fact that this work was done at night and in winter, during wet, windy, and snowy weather, not a single train was delayed during either day or night, a fact that not only speaks well for the method of reconstruction adopted, but also indicates how well the work was organized.

When one of these bridges was stripped, it was found that one of the bottom girder flanges was very badly corroded. This was repaired by burning away the ragged parts of the flange plate section and welding on a new plate.

Apart from the actual saving in money effected by adopting electric welding instead of riveting, which represented $8,700, or 24 per cent on a total estimated renewal cost of $36,100, there was the saving due to non-interruption of traffic and consequent loss of revenue. Delays cause a permanent loss of passenger traffic; the present experience is that, of the passengers who desert railways for buses, only a small percentage return. Finally, there was a complete absence of noise, and the neighborhood was not disturbed as it would have been by pneumatic rivet hammers.



AN ALL-WELDED BRIDGE IN THE UNITED STATES

Chicopee Falls Bridge, Mass., built in 1928 on a 72-deg. skew, was designed for Cooper's E-50 Loading. Each truss span is 134 ft. 8 in. long. The bridge, which contains 80 tons of steel, was erected on the canal bank and launched longitudinally into place. It was built for the Westinghouse Company's spur of the Boston and Main Railroad. Photograph courtesy of Westinghouse Company.

HINTS THAT HELP

Today's Expedient—Tomorrow's Rule

The minutiae of everyday experience comprise a store of knowledge upon which we depend for growth as individuals and as a profession. This department, designed to contain practical or ingenious suggestions from young and old alike, should afford general pleasure not unmixed with profit.

Rubbing Bed Grinds Test Cylinders and Cores

By W. J. Harris

Associate Member American Society of Civil Engineers
Materials and Testing Engineer, Los Angeles County Road Department, Los Angeles

FOR the purpose of studying the strengths and characteristics of concrete pavement, the Los Angeles County Road Department has cut cores from the completed pavement in preference to using cylinders cast on the job. This was done for several reasons: the personal element always present in the making of cylinders is eliminated; and cores cut from the pavement are not only representative of the actual placing, tamping, finishing, curing, and weather conditions, but also permit inspection of subgrade, thickness of pavement, grading of aggregates, density of concrete obtained, and condition of expansion joints. Also, on account of the high strengths now being obtained, the largest available compression machine in this vicinity, with a capacity of 200,000 lb. per sq. in., will not break a cylinder of the size prescribed for the 3-in. maximum-sized rock being used by the department.

TESTING OF CORES PRESENTS PROBLEMS

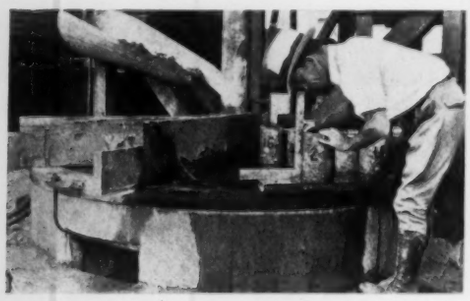
Some problems were encountered in connection with the cores. In Bulletin 14 of the Lewis Institute, H. F. Gonnerman, M. Am. Soc. C.E., has shown that capping materials are most successful when used on carefully molded cylinders permitting uniformly thin caps. The base of a core is frequently very irregular, necessitating caps varying widely in thickness, and causing uncertainty as to the correct length of the specimen and the correction to be used to reduce the break to that of a standard specimen of ratio $\frac{H}{D} = 2$, as required by the standard of the American Society for Testing Materials. Also, to develop the full strength of the concrete, it was thought necessary to allow neat cement caps some time to set. This delay, together with the 48 hours of soaking in water, also required by the standards of the American Society for Testing Materials, necessitated the cutting of cores several days before the time of breaking.

METHOD OF PLANING ENDS OF SPECIMENS

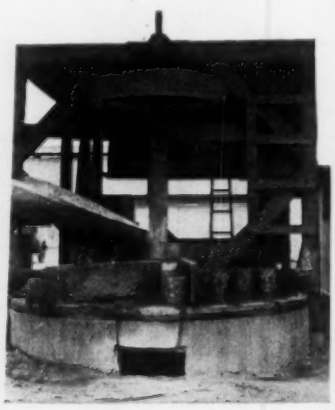
It therefore seemed desirable to find some method of planing off the ends of the specimens. A few experiments were made with a capping material developed by a local laboratory, consisting of a mixture of melted sulfur, which attained a strength of 12,000 lb. per sq. in. as soon as cooled. Some high breaks were obtained with this material, and because of its high strength and permissible speed in breaking, it seemed quite satisfactory as a capping material. Further experiments were made at a local marble plant where it was found that a carborundum "saw" would cut off the end of a 6-in. specimen in about five minutes. Because of minute deflections of the wheel, caused by the non-uniform texture of mortar and rock, a slightly imperfect surface was obtained, which was corrected by placing the specimen on a "rubbing-bed" for a few minutes. Later it was found more economical to grind down even the most irregular specimens on the bed, eliminating entirely the use of the carborundum saw.

To test this method of surfacing, 200 cores were cut in pairs from various pieces of pavement, one set being surfaced and the other capped with neat cement. In almost every case the surfaced core broke higher than its capped duplicate, and the averages of the various groups of surfaced cores ranged from 10 to 25 per cent higher than the capped specimens.

In August 1931, the department purchased a small second-hand rubbing bed, which has now been in use for more than a year. The bed is 7 ft. 6 in. in diameter, and is belt-driven at a speed of 45 r.p.m. by a 7½-hp. motor. A fine beach sand is used as the abrasive and is contained in a sheet-iron bin located above the surface of the bed. A small stream of water is so regulated as to feed the desired amount of sand to the center of the bed, and the overflow is caught in a small trough located underneath the rim of the bed, whence it is conducted to a settling basin. The speci-



The Rubbing Bed and Installation



Checking Ends for Perfect Bearing

The Cores Before and After Grinding

Method of Preparing Cores for Compression Tests

mens are placed against radial partitions, or "stops," which hold them in position and prevent them from turning with the bed. Plenty of sand on the bed makes the grinding process more rapid, while for finishing, a clean bed with less sand and more water is desirable.

TRIANGULAR RACK HOLDS CORES WITH IRREGULAR BASES IN AN UPRIGHT POSITION

Cylinders made in steel molds, with carefully finished ends, can be surfaced in a minute's time on the bed, by placing a hand on the top end of the specimen and rotating it slowly in a radial direction. For ends that are not quite so smooth, a 40-lb. weight, placed on top of the specimen, will greatly accelerate the grinding process. A steel carpenter's square, with legs conveniently shortened, is used to plumb the specimens. Cores with irregular bases and other specimens that will not remain in a vertical position are wedged into the triangular cells of a triangular-shaped wooden rack. With weights on top of the specimens and plenty of sand on the bed, a group of the worst specimens can be ground down in an hour or two.

After the specimen has been taken off the bed, it is polished for a short time on a steel plate with a small amount of emery dust and water. It is then checked for a perfect bearing surface on another plate, which has been machined to a true surface and lightly coated with bluing. Further experiments are needed to show what degree of precision is necessary in this work.

ADVANTAGES OF THE METHOD

This method of surfacing allows the use of specimens that are an integral part of the structure to be tested, and their ends may be made very nearly parallel and normal to the axis, so that the length of the specimen may be determined quite accurately. It has also made it possible to cut cores from high-early-strength concrete, intended for early use by traffic, and to surface and break them within two or three hours after cutting.

The cost of surfacing depends, of course, on the number of specimens and their condition. Carefully molded cylinders can easily be surfaced at a cost of 10 cents per specimen, regardless of numbers. In lots of from 15 to 20, average cores can be surfaced at a cost of 25 cents apiece. The cost of preparing specimens by this method, therefore, compares very favorably with that of capping. Surfacing is now the standard practice in this department.

OUR READERS SAY—

In Comment on Papers, Society Affairs, and Related Professional Interests

Compromise Plan for Subdividing Irrigated Land

TO THE EDITOR: Mr. Welty's excellent paper on "The Subdivision of Irrigated Land," in the May issue, was of particular interest to me, inasmuch as it recalled to my mind similar problems encountered a few years ago while engaged in the drainage of irrigated lands in the West and Southwest.

It appears to me that the logical steps in the development of an irrigation project are as follows: (1) a topographic survey and a well prepared map showing contours, other physiographic features, existing property lines, roads, etc.; (2) layout of an irrigation system; (3) layout of a drainage system; and (4) subdivision of the land into farm units. Too often, through a false idea of economy, Steps 1 and 3 are omitted, or else very much curtailed, and Step 4 is placed ahead of all the others.

The "natural plan," suggested by Mr. Welty, unquestionably has considerable merit. However, the question arises as to whether, under certain conditions, too close adherence to this plan may not result in irregularly shaped tracts comprising the farm units and in other disadvantages. It has been my observation and experience that usually better results will be secured by following only approximately the ridges or drainage divides in the location of irrigation canals and laterals and, more especially, by following only approximately the depressions or draws in the location of drainage ditches, making slight deviations in order to secure smooth alignment.

It is true that for projects laid out as I have suggested, in places there may be slight deviations from uniformity of ground slopes from the irrigation canals and laterals to the drainage ditches. In fact, there may be a few relatively high areas not immediately adjacent to the irrigation canals and laterals and a few relatively low areas slightly to one side or the other of the drainage ditches. It is believed, however, that such irregularities may be remedied by grading down the high places and filling up the low places by team and scraper methods at costs that are not prohibitive, especially considering the present low rates for labor and other items. The material, especially the top soil excavated from the drainage ditches, instead of being deposited in spoil banks may be utilized in filling the low places.

Property lines should be made coincident with irrigation canals and laterals, and cross lines for additional property lines should be run from canals and laterals to drainage ditches. Where the irrigation and drainage systems are laid out as suggested, I believe that, except where the topography is very irregular, such cross lines may be run as straight lines with a large number of them parallel. It will readily be seen that the tracts or farm units thus laid out will be polygons rarely more complex than quadrilaterals and, in a large number of cases, may be reduced to tracts which are trapezoidal or rectangular in shape.

Such a system is in effect a compromise between the "regular or rectangular plan" and the "natural plan" and combines, to a large extent, the desirable features of both. The advantages of such a compromise plan over the "natural plan" are as follows: (1) a shortening in length of the irrigation canals, laterals, and drainage ditches, and consequent increased gradients and increased capacities for given cross section areas; (2) reduced costs of surveying and mapping, made possible by the more desirable shapes of the individual tracts; (3) increased convenience in farm operations; (4) improved appearance due to the possibility of elimination or partial elimination of undesirable and unsightly spoil banks along

the drainage ditches; (5) improved appearance as to alignment of the irrigation and drainage systems, the irregular alignment being replaced by a series of regular smooth curves joined by tangents; and (6) improved appearance in the shapes of the individual tracts or farm units.

Too much emphasis cannot be placed upon the importance of giving sufficient preliminary study to each individual project in order to determine which plan is required to meet the peculiar conditions.

WILLIAM N. HALL, Assoc. M. Am. Soc. C.E.

Washington, D.C.
September 18, 1932

Limitations in Pile-Driving Formulas

TO THE EDITOR: In his article in the August issue, Mr. Morrison has presented some interesting data in his comparisons of the Hiley pile-driving formula and the *Engineering News* formula. His charts and tables indicate wide variations in the results obtained in calculating the carrying capacities of piles by these two formulas and the tables show what appear to be important inconsistencies in the *Engineering News* formula.

There are twenty-five or thirty pile-driving formulas in existence, some of them very simple and others fairly complicated. When published, each of them was accompanied by explanations and suggestions as to its use, and the engineer who attempts to supply a formula without due regard to its limitations is very apt to find

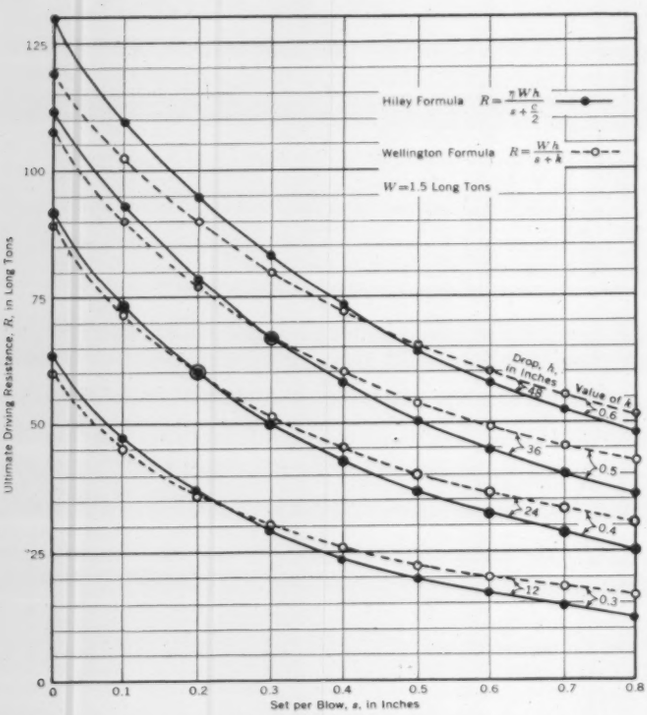


FIG. 1. RECALCULATION OF MR. MORRISON'S DATA ON PILE FORMULAS

inconsistencies. When Wellington published his formula, he realized that he was proposing a relatively simple solution for a very complicated problem and he placed certain restrictions on the values that could safely be assigned to the various factors in the equation. He called attention especially to the arbitrary constant in the denominator of the equation, which he gave as 1.0 for drop hammers and 0.1 for steam hammers. For drop hammers he stated that the fall was to be from 20 to 30 ft. and the interval between blows from 5 to 20 sec. For steam hammers, he said: "As a rule the interval of time between blows is not more than one-tenth to one-twentieth as great . . . therefore, the constant 1 in the formula . . . should be not over one-tenth as great, if so much."

In his paper Mr. Morrison deals entirely with drop hammers, and in most of his calculations the heights of fall are from 1 to 5 ft. These short drops certainly provide more rapid hammer action than Wellington contemplated in his drop-hammer formula, and therefore the arbitrary constant in the denominator of the Wellington formula should be given a value somewhere between 0.1 and 1.0 in order to follow the principles laid down by Wellington.

With a series of values of this constant, beginning with 0.3 for a 12-in. drop and increasing by 0.1 for each additional foot of drop to 0.7 for a 60-in. drop, Mr. Morrison's Fig. 4 was recalculated and replotted and is given herewith as Fig. 1. What Mr. Morrison calls "safe" loads in his Tables I, II, and III are really "ultimate" loads, but a recalculation of these tables with varying values of the Wellington constant will eliminate all the apparent inconsistencies in the results obtained with the Wellington formula. All the curves shown in these figures are families of hyperbolas. They are asymptotic to the s-axis and have vertical asymptotes which cut the negative s-axis where $-s$ has the value of the constant in the denominator of either formula. While negative values of s have no physical meaning, the importance of the constant in the denominator can be seen from the fact that its value determines the shape of the curve and its position on the curve sheet.

I do not suggest a modification of the *Engineering News* formula so that calculations made with it will check with the results of the Hiley formula. I would however call attention to the fact that the Hiley formula contains several constants; whereas the Wellington formula has but one arbitrary constant, and it is necessary to vary this constant when calculations are being made with data that lie beyond the limits laid down by the author of the formula. Pile-driving formulas are not simply algebraic equations, and comparisons of results obtained from several formulas should be made only after full consideration has been given to the mathematics and mechanics by means of which the equations were derived. This procedure will at least eliminate most of the apparent inconsistencies.

A. E. CUMMINGS, Assoc. M. Am. Soc. C.E.
District Manager, Raymond Concrete Pile Company

Chicago, Ill.
September 28, 1932

Stability of Arch in Soil

TO THE EDITOR: In the May issue of CIVIL ENGINEERING, Mr. Meem discusses my paper, "Design of Tunneled Sewers in Unstable Ground," which was published in the April issue. He quotes from my paper as follows: "So long as there continues to be uncertainty as to the ultimate durability of the soil arch and as to the degree of protection afforded by it, the engineer is safer in discarding this arch as an effective factor in sewer design." He then comments: "If such conditions existed, tunnel operations could not be carried on at any considerable depth even in normally dry soil." Actually, of course, again quoting from the original paper, "If a tunnel is driven through the subsoil, the weight of the superincumbent soil is transferred to each side by arch action"; and Mr. Meem is quite correct in pointing out the difficulty that would arise in tunneling through soil that possessed no arching properties.

My paper, however, was concerned with the quite distinct problem of how long this soil arch continued to function in full force. Mr. Meem offers no comment on such a time-pressure relationship. Certainly the familiar pipe experiment has no direct bearing on this phase of the subject. In my paper, I pointed out that the stability of the arch in sand is dependent on the opportunities afforded for rearrangement of the sand grains, while in the case of saturated clay some redistribution of stress is a development intimately connected with the subsequent changes in water content of the clay.

Readings from pressure cells in clay, placed at various locations in three Detroit water-supply tunnels, demonstrate the existence of stress redistribution. The results indicate an initial decrease in pressure after installation, and then a gradual increase of about 10 per cent in the period of from one to two years for which results have so far been made available. The average for the latest readings of crown pressure represents about 80 per cent of the weight of the overlying soil.

Experience, experimental evidence, and theory all point to the possibility of redistribution of pressure after the completion of the tunnel. To design for such a contingency may mean a service to future generations at a negligible increase in first cost. At any rate, the consideration of all factors involved is the basis for rational design.

The theory behind such experiences as that related by Mr. Meem in connection with the construction of the old Battery Tunnel is developed by Terzaghi in his *Erdbaumechanik*, pages 203–210.

ROBERT G. HENNES, Jun. Am. Soc. C.E.

Detroit, Mich.
September 6, 1932

Adding Accuracy to Plotting Soundings

DEAR SIR: The article by William D. Ayers on "Soundings by Triangulation Intersection" in the September number, in the department, "Hints That Help," brings to mind a somewhat different solution of the same problem. In 1914 the survey party with which I was working was plotting soundings preliminary to the development of Port Newark on Newark Bay. The intersections locating the soundings were often 3 or 4 ft. away from the plotted transit points because of the scale used. It was found that the use of a protractor even as large as 14 in. in diameter was too inaccurate.

After experimenting, the method finally used was to plot natural tangents along a strip of paper about one-half inch wide. These strips of paper were then tacked over the drawing at right angles to, or parallel with, the base line. The natural tangents were multiplied by a number, such as 2,000, so that when the strips of paper were attached to the drawing in the correct locations they became in effect a large scale protractor. On a map drawn to the scale of 100 ft. to 1 in., the effective diameter of the protractor, when the tangents were multiplied by 2,000, was approximately 40 in.

T. R. GALLOWAY, Assoc. M. Am. Soc. C.E.
The New York Edison Company

New York, N.Y.
October 6, 1932

Bearing Capacity of Steel Piles

TO THE EDITOR: In their paper on "Steel-Pile Foundations in Nebraska," in the September issue, Messrs. Mason and Ogle have made brief references to two points that might profitably be further considered. These points are (1) the tests of bearing power of the steel piles, and (2) the flexibility of these piles. The tests mentioned show resistance to pulling of 1.5 to 4.4 times the *Engineering News* formula safe load, and show ultimate load capacities from about four to more than ten times the safe load by the same formula.

The Gothenburg, Pender, and Wood River test piles were in coarse sand and water, and no settlement occurred under any load. The Pender and Wood River piles were not loaded to capacity. It would have been very interesting to have had the ultimate load for these locations. The Fairbury test piles were in comparatively thin strata of dry sand and gravel, with clay underneath, and were loosened under loads of from 2.5 to 5 times the *Engineering News* formula capacity. The Gothenburg piles failed as steel columns. There was no settlement. This seems to indicate that the friction or gripping power of sand in water is much greater than that of finer-grained materials containing a much smaller percentage of moisture.

The authors have called attention to the ability of a steel pile to stand long-continued hard driving. With proper accounting for the material into which the pile is driven, a suitable formula should give a more accurate estimate of the bearing capacity of a steel pile than of one of another material because the last hammer blow always falls on solid metal, while with other materials some of the force may be spent in crushing the top.

As pointed out in the paper, the steel H-sections are quite flexible. This characteristic should be given careful consideration in planning their use. The authors mention designs in which expansion and contraction of the superstructure are taken care of by the flexing of the steel pile bents, which seemingly is very proper design.

This quality, however, is undesirable in abutments and retaining walls. In some bridge abutments built with single rows of steel piles, it has been observed that all of the opening left for expansion has been closed up completely at temperatures below 75 deg. fahr., and the only explanation is a slight tipping of one or both abutments. This may be due to earth pressures, or to expansion of the concrete pavements approaching the bridges, or to both. Therefore it seems that such structures should be built of two lines of piles braced together, or with one line battered, or of some other design so as to reduce movement to a minimum.

The tests again emphasize the fact that the character of the soil is an important element in any estimate of pile-load capacities. Additional tests would be valuable. The flexibility of steel piles is an asset for some conditions, but a detriment for others, and good judgment is required in using them.

WILLIAM GRANT, M. Am. Soc. C.E.

Lincoln, Nebr.
October 8, 1932

H-Piles for Bridge Bents

DEAR SIR: I read with great interest the paper by Messrs. Mason and Ogle in the September issue. It is evident that the authors have had abundant experience with a type of construction which, although it has been used only occasionally at scattered locations throughout the country, has so much to recommend it that the data supplied by them should lead to its more frequent and more confident use.

H-sections driven as bearing piles are being used more and more for bridge falsework. Since the engineers in charge of such construction are not tied down to old specifications for allowable load and are in a position to use their own judgment, they have recognized that the safe capacity is far in excess of that obtained from the *Engineering News* formula. The test data given by Messrs. Mason and Ogle and their recommendation of a capacity based on column action are valuable confirmations. It would be desirable for them to add what they consider the minimum driving requirements (rate and depth of penetration at completion of driving, character of soil, etc.) so that their column formula recommendation may be in order.

It is noted that Messrs. Mason and Ogle refer especially to driving in sand and gravel. In gravel, particularly of large size, any transverse bent of ordinary piles will deflect considerably in driving and require forcing into line at the top for capping. With steel piles, it would appear that the force required to draw the tops into line would be greater and should receive attention. It would be desirable for the discussion to bring out: (1) what frame or jig for driving will ensure that the piles in a bent drive parallel, if this can be achieved; and (2) what type of cap beam (referring to bents not encased in concrete) is best adapted to the duty of lining up the tops of the several piles in a bent, if and when they do not drive parallel.

In this latter connection, I am not satisfied with the stability of a simple transverse beam resting across the tops of the piles. A frequently used construction comprises two channels and a cover plate, with the channels shop-punched for connection to the pile flanges, which are drilled after driving and cutting off. If the force required for lining up is considerable, I wish to submit for consideration the use of an H-section as cap, with the web laid horizontal and the clear distance between flanges only slightly greater than the width over the flanges of the H-piles. This would be economical and also very stiff. Stringer attachments would be shop-welded between the upstanding flanges.

I wish especially to commend the authors' suggestions for permitting successive pile piers or bents to bend, and taking up the expansion at occasional stiffer piers or towers. Using I-beam spans from 40 ft. up for highway trestles or viaducts, as is now very usual, it is useless to expect the spans to slide on slender

piers or bents. They are bound to carry the latter with them in their movements; and the design should contemplate this bending in the piers or bents, the stresses from which are quite permissible when H-sections are used for the columns.

JONATHAN JONES, M. Am. Soc. C.E.
Chief Engineer, McClintic-Marshall Corporation

Bethlehem, Pa.
September 4, 1932

Steel Piles Superior

DEAR SIR: The paper by Messrs. Mason and Ogle, in the September issue, is on an interesting and vital subject. The use by our state highway departments and by the U.S. Bureau of Public Roads of the information given therein would save our taxpayers millions of dollars.

During the past 35 years the Monarch Engineering Company has built over 4,000 bridges on steel piles. During the first 20 years there was great opposition. Throughout this experience in building bridges on steel piles, we have never had a failure. None of these bridges has settled, or given any trouble.

In September 1923, there was a flood in the Powder River at Arvada, Wyo. We had previously built a 160-ft. steel span bridge, with the floor 7 ft. above the previous high-water mark. In this particular flood the water reached a height of 30 ft. 6 in. above the low-water mark, or 15 ft. above any previous high-water mark, and covered the floor to a depth of 8 ft., but the bridge stood firm.

The authors are too modest and overly cautious in their tests and conclusions of permissible loading. We estimate that a steel pile driven to refusal will safely carry 100 tons. The *Engineering News* formula, which will not apply on steel piles, has resulted in much waste on wood piles, causing brooming and a mushroom condition below the surface. We are amazed to note the splintered condition of old wood piles whenever we have occasion to dig them out.

At 60 tons each a bent of three steel piles will have a bearing power of 180 tons, or three times the strength of a bent of five creosoted wood piles good at 12 tons each. Yet three 8-in. steel piles driven will cost no more than five creosoted wood piles. No greater in first cost, they have at least from three to six times the strength of the wood pile bent described above. From the standpoint of length of life, Mr. Mason's tests, which agree with our experience, show a corrosion loss of 2 per cent in 25 years, without paint. Assume the corrosion loss to be uniform (although it is retarded as the rust coat thickens), there would be a loss of 16 per cent in 200 years. Even adding 50 per cent of this and assuming the total loss to be 25 per cent, 75 per cent of the strength of the steel piles is still left, a much greater amount than the bearing power of the wood piles when new.

JOHN A. CROOK, Assoc. M. Am. Soc. C.E.
President, Denver Steel and Iron Works

Denver, Colo.
October 3, 1932

Future Demand for Irrigation

TO THE EDITOR: Colonel Robins' paper on "Improvement of the Columbia River," in the September issue, is a most interesting digest of the recent report to Congress by the U.S. Corps of Engineers. It reflects much credit on those who have participated in its preparation. Future demand for irrigation water and electrical energy relates to many factors, including the population growth of the entire country, redistribution of population, and tariff arrangements for successful marketing abroad of the products of irrigated farms and electrochemical manufacturers.

In connection with the future demand for agricultural products in this country, it was only three or four years ago that vital statisticians were discussing the possibility of a maximum population for the continental United States of perhaps 300,000,000, based on food production. Professor Pearle estimated that a maximum figure of about 200,000,000 would come by 2100. Now the best available data indicate that, before 1960, our country will reach a maximum population of less than 145,000,000 unless some unforeseen changes occur in immigration. It is rather difficult for many to realize how quickly we have reached a position where our emigration exceeds our immigration, and how marked has become the falling birth rate, not only of native stock but of practically all of our peoples in the larger centers of population.

Twenty-five years' experience with irrigated land in the Snake River Valley leads me to believe that what is needed now is not new irrigation projects but more reliable water supplies for sections of existing projects. Attempts have been made to irrigate more acreage than can be relied upon during seasons of low or poorly distributed precipitation. Correction of this has been effected in part by building storage reservoirs; but even in some of these cases irrigators having junior rights in storage water may still suffer from the inadequacy of the supply actually available at the farm ditches when water is imperative for maturing crops.

GEORGE W. FULLER, M. Am. Soc. C.E.
Consulting Engineer

New York, N.Y.
September 9, 1932

Revised Formulas for Designing Footings

TO THE EDITOR: The following errors occurred in my article, "Designing Footings by Charts," published on page 648 of the October issue of CIVIL ENGINEERING:

Equation 7 should read:

$$A_s = \frac{0.504\,Pb}{148{,}750},$$

and Equation 9 should read:

$$A_s = 0.00109\sqrt{P}\,b.$$

PRESTON M. GEREN, M. Am. Soc. C.E.
Chief Engineer, Wyatt C. Hedrick, Inc.

Fort Worth, Tex.
October 17, 1932

Hydraulic Radius Difficult to Determine

DEAR SIR: The exceedingly interesting article by Messrs. Vogel and Dean, in your August issue, on the factors of similitude to be applied to hydraulic tests brings to mind a problem to which I take this occasion to call attention, as I believe it has never yet been sufficiently recognized by hydraulic investigators. This is the relation between Kutter's (or Manning's) N and R. The authors state that the value of N in small-scale models appears to be higher than would be expected and that they believe it varies with R and S. It does vary with R as long as R is the very vague and indefinite quantity it must be in all computations dealing with large natural channels. Since R is a function of wetted area and wetted perimeter, it cannot be more accurately determined than either of these values. While areas can usually be measured with reasonable accuracy, the wetted perimeter in a natural river under average conditions is a term existing only in hydraulic treatises and formulas, but never determined in reality. For instance, in a river with a bottom consisting of boulders or pebbles, the real wetted perimeter is the sum of the wetted perimeter of each individual stone, a line obviously much longer than one obtained by taking points at 20, 50, or 200-ft. intervals, as the case may be.

If the actual wetted perimeter could be determined and the hydraulic radius R computed from it, R would become much smaller and, figuring N from this R, N again would become smaller; and it would then be a measure of friction between water and the relatively smooth surface of each stone instead of a composite value obtained by a rough approximation of the wetted perimeter. The length of the latter is a function of the accuracy with which it

is taken; the closer the distance between points measured, the longer the wetted perimeter and vice versa. Real accuracy could only be obtained by taking an infinite number of points. In a river with a very flat and sandy bottom this may not make so much difference, but when the bottom is rocky a wetted perimeter based on points taken at 20 or even 10-ft. intervals is far away from the real wetted perimeter.

I believe that this sufficiently illustrates my point: that is, that values for N, R, and hydraulic perimeter cannot be compared or deductions made from their comparison if the wetted perimeters have not been determined with the same absolute accuracy. From an examination of numerous flow and backwater computations on large natural rivers, I believe that it is wasted effort to determine and use wetted perimeters and values for N and R derived from them. The use of mean depth instead of R gives just as good results, is much simpler, and substitutes real dimensions for imaginary ones by putting all the not directly measurable characteristics of a river section, to which belongs the wetted perimeter, into the coefficient N.

This is, of course, not a suggestion to discard the use of the hydraulic radius generally. The term, however, as applied to natural rivers, needs a clear definition, and this problem may be one of many that can be solved best by model tests such as those described by Messrs. Vogel and Dean. The Mississippi River Commission and its research staff are to be congratulated upon having the equipment to conduct such tests and the will to acquaint the profession with the results obtained.

PAUL E. GISIGER, Assoc. M. Am. Soc. C.E.
Safe Harbor Water Power Corporation

Baltimore, Md.
September 23, 1932

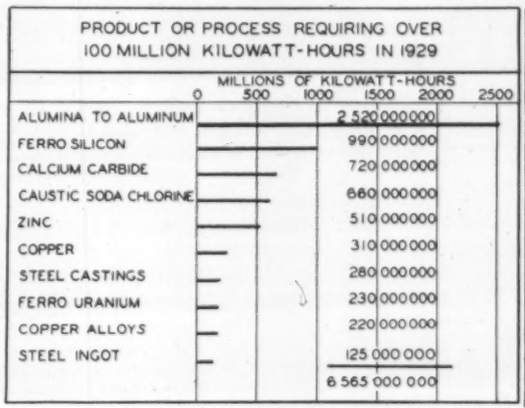

PRODUCT OR PROCESS REQUIRING OVER 100 MILLION KILOWATT-HOURS IN 1929
MILLIONS OF KILOWATT-HOURS
0 500 1000 1500 2000 2500
ALUMINA TO ALUMINUM 2 520 000 000
FERRO SILICON 990 000 000
CALCIUM CARBIDE 720 000 000
CAUSTIC SODA CHLORINE 660 000 000
ZINC 510 000 000
COPPER 310 000 000
STEEL CASTINGS 280 000 000
FERRO URANIUM 230 000 000
COPPER ALLOYS 220 000 000
STEEL INGOT 125 000 000
6 565 000 000

Fig. 1. Total Consumption

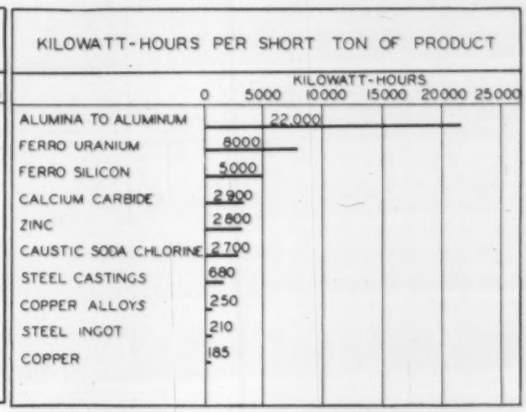


Fig. 2. Consumption per Ton of Product

ELECTRIC ENERGY REQUIRED BY TEN MAJOR INDUSTRIAL PROCESSES

Electric Power in Industry

TO THE EDITOR: In connection with Colonel Robins' article on "Improvement of the Columbia River," which appeared in the September issue, it may be of interest to consider some results of a study of the use of electric power in industry, made at Washington, D.C., by a trained scientist and submitted as an appendix to the Columbia River Report. Although these findings were not used in estimating the rate of power-market growth as set forth in the report, they may be taken as authoritative.

In 1929, electrochemical processes in the United States consumed 7,000,000,000 kw-hr. of electrical energy, or about one-tenth of the total generation. In Fig. 1 is shown the kilowatt-hours consumed by ten industries, each of which required upward of 100,000,000 kw-hr. during that year. It will be noted that the process of deriving aluminum from its hydroxide, alumina, heads the list.

The kilowatt-hours required for each short ton of product for the ten processes listed in Fig. 1 are shown in Fig. 2. Aluminum again comes first with 22,000 kw-hr. per short ton, ferro-silicon second with 8,000, and calcium carbide third with 5,000 kw-hr. A difference of 1 mill per kilowatt-hour in the cost of power would, then, effect a change of $22, $8, and $5 per ton, respectively, in the cost per ton of these three products.

In Fig. 3 is shown the production of aluminum in the United States by years from 1913 to 1930. At the left are the short tons and at the right the corresponding consumption of electrical energy, assuming 27,000 kw-hr. per short ton of product, the amount required to produce aluminum by the all-electric process. In 1913 the production amounted to only 23,000 short tons. By 1930 it had increased to 114,500 short tons, an average rate of increase of 10 per cent compounded annually. If this rate of growth were continued, it would show a production of nearly 300,000 tons in 1940, and a total power consumption of eight billion kilowatt-hours, or an increase of five billion kilowatt-hours in ten years. Assuming an 85 per cent load factor, this would necessitate new installations totaling 670,000 kw. in the next ten years for this one industry alone.

The ferro-alloys and the fertilizer industries show rates of growth somewhat comparable to the aluminum industry. The fact that five billion tons of phosphate rock, out of a total of six billion for the entire United States, are to be found in the drainage basin of the Columbia River in Idaho, indicates that the fertilizer industry will sooner or later require the development of large blocks of Columbia River power.

In 1929 the paper industry in this country required in excess of two billion kilowatt-hours of mechanical energy. Although this load does not show a great increase for the country as a whole, it may be expected to show an increase in the Pacific Northwest as both the raw material and cheap power are available there.

Power for these industries cannot be generated by steam because it is too costly. For the same reason, it cannot be generated by water-power plants of the ordinary type. Neither can it be obtained from otherwise favorable water-power sites far inland, as the cost of transmitting the energy to tidewater or transporting the raw materials to, and the finished products from, the site would be too great.

Where, then, if the electrochemical industries, and the industries requiring large blocks of mechanical energy, are to show a continued growth in the United States, is the cheap power to come from? The answer would seem to be that it is to come from the Columbia River. The cost at which it may be developed, the size of the blocks in which it may be developed, and the proximity to tidewater are the reasons back of this conclusion.

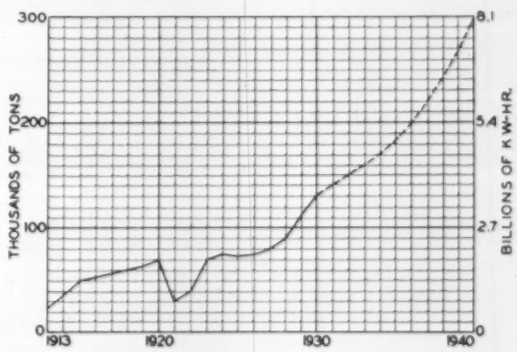


FIG. 3. PAST AND FUTURE GROWTH IN THE USE OF POWER FOR MANUFACTURE OF ALUMINUM

HAROLD A. RANDS, M. Am. Soc. C.E.
Hydro-Electric Engineer
U.S. War Department

Portland, Ore.
September 30, 1932

SOCIETY AFFAIRS

Official and Semi-Official

Inspiring Fall Meeting at Atlantic City

Ideal Surroundings and Excellent Program Combine to Form Memorable Gathering

MEMBERS AND GUESTS assembling from the four corners of the country gathered under ideal surroundings to enjoy the Fall Meeting in Atlantic City, October 5–8. As predicted, sunny skies and fine autumn weather marked the entire week, with the single exception of Thursday afternoon.

Coming as it did somewhat after the rush of summer visitors, this gathering was enabled to enjoy in quiet the facilities afforded by the famous resort. Every convenience of a well appointed hostelry, familiar with the needs of society conventions, was made available by the Chalfonte-Haddon Hall Hotel.

ENGINEERING IN THE PHILADELPHIA DISTRICT

Convening on Wednesday morning, October 5, 1932, the meeting was greeted by local civic officers; received the keys of Atlantic City; and listened to an appropriate response by the President of the Society. These formalities over, the remainder of the session was devoted to a discussion of the monumental improvements now being completed in and around the Pennsylvania Railroad terminal in Philadelphia.

Following a well attended buffet luncheon, the afternoon session, likewise of general engineering value, was devoted to a topic of outstanding interest—the regional plan developments in the Tri-State District surrounding Philadelphia. Discussion of the many topics allied with this large problem was concluded in ample time to prepare for the evening's activity.

In the interim, many members could not resist the lure of the famous boardwalk. The fine October day, the far-reaching lines of breaking surf, and the brisk promenade as the day drew to a close and twilight came down over the shore and the sea—all combined to form a long-to-be-remembered experience.

A NOTABLE SOCIAL EVENT

One of the particularly enjoyable features of the meeting was scheduled for that same evening, in the form of a dinner at the headquarters hotel. Although every meal was in itself an event, this dinner seemed to outdo the generous preparations made for it. Instrumental and vocal music enlivened the repast, during which many new friendships were made and many old ones renewed.

Members and guests were therefore in a most agreeable mood when order was called and the more formal exercises began. The adjustment of economic affairs to the tempo of the day formed the text of most of the talks. Charles D. Marx, Honorary Member and Past-President, spoke of the work of the Reconstruction Finance Corporation, to which he and other members of the Society are giving their best efforts. Following Professor Marx, Willard Chevalier, Member of the Society, gave his own inspiring interpretation of "Lessons of the Past Two Years." Next, Conrad N. Lauer, President of the American Society of Mechanical Engineers, brought greetings from the sister Society, mentioning particularly the possibilities of joint Society activities in the newly formed Engineers' Council for Professional Development. The last speaker, Elisha Lee, vice-president of the Pennsylvania Railroad Company, gave a graphic account of the conditions confronting American railroads and presented a solution of the problem, as he saw it, to the best interest of all concerned. From every standpoint, it was a very successful evening.

TECHNICAL SUBJECTS FEATURED

For the Thursday technical meetings, one of the upper floors of the hotel was given over to the Society. Registration headquarters, meeting rooms, lobbies, and committee rooms were in constant use. The Sanitary Engineering Division gave considerable attention to the questions of refuse disposal and district sanitary sewers. Following this, the problems involved in sewage disposal along the New Jersey coast were exhaustively discussed.

Simultaneously, a joint session of the City Planning and the Surveying and Mapping Divisions was in progress. These Divisions found in the question of surveys for regional and city planning a topic that was of common value and interest. A worthwhile discussion ensued.

That afternoon, for the only time during the entire meeting, the weather went contrary to form and expectation. The heavy rain "washed out" the proposed golf tournament, confining activities to small indoor social groups. The ladies were much more fortunate, or perhaps more forehanded, in their selection of that time for a luncheon and bridge.

No special plans were made for dinner on Thursday evening, the intent being to permit special groups of friends to make up their own dinner parties. Following dinner, however, an extensive entertainment was provided. As guests of the Philadelphia Section, the party enjoyed a varied program of musical and artistic numbers. Finally, a brief period was given over to dancing before it was time for the entertainment to break up.

DIVISION MEETINGS COVER VARIED FIELDS

On Friday, Division meetings again occupied the forenoon in simultaneous session, the Sanitary Engineering Division considering the problems of water supply; the Highway Division taking up economic questions, with especial emphasis on traffic control; and the Engineering-Economics and Finance Division devoting most of its attention to public works.

Immediately after lunch, the postponed golf tournament got

THE LADIES RECEIVED A REGAL WELCOME AT ATLANTIC CITY

under way at the Seaview Golf Club in Absecon, making up for the delay in the increased pleasure of the contestants. When the official scorekeeper had finally adjusted the totals, it was discovered that the prizes went to John H. Caton, 3d, and Thomas P. Watson, Members of the Society. If, as some of the older members claim, this is really the first occasion on which those attending a regional meeting have competed, it has set an excellent example for others to follow.

Coincident with the tournament, an active conference of Student Chapter representatives was taking place at meeting headquarters. In another part of the hotel, tea was being served for the ladies. The evening was spent in recuperating from the many activities of the meeting and in anticipation of the following day's trip.

VALLEY FORGE AT ITS BEST

As the final event of the meeting, an all-day excursion was arranged for Saturday. Starting immediately after breakfast, the large party left by train and automobiles for Philadelphia, where they were met by additional representatives of the Philadelphia Section. During the remainder of the forenoon, advantage was taken of the favorable opportunity to examine and study at close range the great changes taking place in the heart of Philadelphia in connection with the Pennsylvania Railroad improvements. Those who wished had an opportunity to visit the many historic sites in this Colonial city.

When the members of the party reassembled, they were served with an excellent lunch in the new 30th Street Station itself. Immediately thereafter, buses were waiting to convey them on another sightseeing tour. Traveling through many of the picturesque suburbs of Philadelphia, the party made its objective one of the notable sights in all America—Valley Forge. Although familiar to many of the members, this locality is of never-ending interest to Americans. A perfect autumn day lent special glamor to the beautiful setting. Fittingly, it brought to a close a Fall Meeting that was on a continuous high level of excellence.

To complete the record of the Atlantic City Meeting, note must be made of the approximate attendance at the various functions. In round numbers this may be given as follows:

General registration	600
Wednesday morning—general meeting	130
Wednesday afternoon—general meeting	100
Wednesday evening—dinner	160
Thursday morning—Technical Divisions:	
Sanitary Engineering Division	60
Joint session, City Planning and Surveying and Mapping Divisions	35
Thursday evening—entertainment	375
Friday morning—Technical Divisions:	
Sanitary Engineering Division	50
Highway Division	35
Engineering-Economics and Finance Division	45
Friday afternoon:	
Golf tournament	20
Student Chapter conference	70
Saturday—Philadelphia trip:	
Luncheon	200
Valley Forge	150

COMMITTEE'S EFFORTS BEAR FRUIT

Credit for making the entire meeting a notable one should be accorded to the local committees of the Philadelphia Section. Literally, for months, they have been laying plans and perfecting details. The result spoke for itself in that no contingency found them unprepared. From the general conception down to the minutest detail, the plans were ample. Space permits only the recognition of the various committee chairmen, as follows: F. O. Dufour, General Chairman; J. W. Follin, Assistant General Chairman; C. A. Howland, Secretary and C. E. Myers, President, Philadelphia Section; Mrs. Henry J. Sherman, Chairman, Ladies' Reception Committee; Mrs. Robert Farnham, Vice-Chairman, Ladies' Committee; Charles H. Stevens, Finance; T. P. Watson, Activities; C. A. Howland, Information and Service; W. R. Scanlin, Transportation; Clark Dillenbeck, Publicity; H. W. Latta, Hotels; C. S. Shaughnessy, Registration; Henry J. Sherman, Technical Meetings and Discussions.

Fortunately it will be possible to reproduce in generous measure the salient features of the technical papers. These abstracts will be found in the December issue of CIVIL ENGINEERING. To all those in any way responsible for this meeting, the Society is greatly indebted, as will be evident from this brief account and from the prepared technical papers to appear later.

Honorary Members Elected by Board of Direction

At the meeting of the Board of Direction at Atlantic City, three well known civil engineers, all Members Am. Soc. C.E., were made Honorary Members: Lincoln Bush, of East Orange, N.J.; John E. Greiner, of Baltimore Md.; and Charles L. Strobel, of Chicago, Ill. In view of the recent deaths of William Barclay Parsons and John R. Freeman, these additions will increase by only one the number of Honorary Members.

Secretary's Abstract of Board of Direction Meeting, October 3 and 4, 1932

THE BOARD OF DIRECTION met at the Chalfonte-Haddon Hall Hotel, Atlantic City, N.J., on October 3 and 4. Present were Herbert S. Crocker, President; George T. Seabury, Secretary; Otis E. Hovey, Treasurer; and Messrs. Black, Buck, Chester, Coleman, Dusenbury, Enger, Gregory, Henny, Herrmann, Hoffmann, Holleran, Lupfer, MacCrea, Mead, Mendenhall, Morse, Riggs, Singstad, Charles H. Stevens, J. C. Stevens, Stuart, Thomas, Tuttle, and Waite. The list includes all living Board members.

Resolutions Regarding Deceased Officers

The death of Charles Warren Hunt, Secretary of the Society from 1895 to 1920 and since that date Secretary Emeritus, was reported to the Board, which adopted a resolution recounting the services rendered the Society by Dr. Hunt throughout his long and active official connection and recording appreciation of those services. This is to be incorporated in the minutes, and a copy is to be transmitted to Dr. Hunt's family in the form given on another page of this issue.

The death of John R. Slattery, M. Am. Soc. C.E., Director from District No. 1, was reported to the Board. Thereupon it adopted a resolution of sorrow and sympathy, which also is to be incorporated in the minutes and a copy of which is to be sent to his family. Copy of the resolution adopted is given in full elsewhere in this issue. Colonel Slattery's term extends to the close of the next meeting of the Board, and no appointment was made for the unexpired part of the term.

Minutes Approved

Approval was given the following minutes: Board of Direction meeting, July 4–5, 1932; Executive Committee meeting, July 6, 1932; and Executive Committee meeting, October 2, 1932.

Nominee for President of the Society

It was reported to the Board that the Nominating Committee had met at the time and place of this meeting and in accordance with the Constitution had reported to the Secretary its unanimous selection of Alonzo J. Hammond, M. Am. Soc. C.E., as the "official nominee" for President for the coming year.

Society Meetings for 1933

On recommendation of the Executive Committee, the Board of Direction voted to hold no Spring Meeting in 1933. The Convention had already been determined upon, to be held in Chicago in the latter part of June, during "Engineers' Week." No action was taken in regard to a 1933 Fall Meeting.

Technical Division Executive Committee Members

The By-laws were changed, in accordance with notice given at a previous meeting, to the effect that the members of the Executive Committees of the Technical Divisions shall be appointed by the Board of Direction from nominations made by the Nominating Committees of the Divisions with or without recommendation by the Executive Committees of the Divisions. This method will replace the cumbersome and expensive system of balloting which has obtained heretofore. Appointees to these offices are listed on a succeeding page.

Puerto Rico Section

In accordance with the request of the Porto Rico Section, and conforming to the Act of Congress determining the proper spelling of the island, the name was changed from the Porto Rico to the Puerto Rico Section.

Prizes Awarded

Adopting the recommendation of the Society's Committee on Prizes, awards for 1932 were made to the authors listed elsewhere in this issue for their respective papers.

Alfred Noble Prize

The Alfred Noble Prize was awarded to Frank M. Starr, Associate Member of the American Institute of Electrical Engineers, who is an engineer of the General Electric Company, Schenectady, N.Y., for his paper entitled "Equivalent Circuits," which appeared in the *Transactions* of the American Institute of Electrical Engineers (Vol. 51, June 1932).

Honorary Members

The Board elected to Honorary Membership Lincoln Bush, John E. Greiner, and Charles L. Strobel, all Members Am. Soc. C.E.

American Engineering Council

To the President was given power to name representatives to the American Engineering Council to fill such terms expiring on January 1, 1933, as are to be available this year under a basis of representation that may be a modification of the present one.

A committee of three members of the Board was authorized to investigate the Society's entire relationship with the Council and to make recommendation to the Board at its next meeting; this to enable the Board to make definite determination at that time as to whether or not the Society's membership in the Council is to be terminated.

Disciplinary Action

The Board of Direction gave very careful consideration to two cases of alleged unprofessional conduct, one of which resulted in expulsion from the Society.

Standing and Advisory Committees

Reports were received from Standing and Advisory Committees. The Report of the Research Committee was referred to the Executive Committee for consideration in connection with the preparation of the 1933 budget, and the report of the Local Sections Committee was referred to a committee to be comprised of Board members, for further analysis and report.

Committee on Public Works

The work of the Committee on Public Works was reported on at length by its chairman. He told of the efforts of the committee culminating in that section of the Relief and Construction Act of 1932, designated as Title II and providing for the extension of Federal credit to solvent states, counties, municipalities, and other political subdivisions to assist them in carrying on what are now termed "self-liquidating" public works. He detailed further the administration of the act and the progress made since its passage.

Value of Research on Hydraulic Fill Dams

A committee was authorized to study the several practical features, such as cost, scope, and value, of the work that might be done if a Society committee were to be appointed to investigate Tests for Materials for Hydraulic Fill Dams.

Cooperation with Members in Arrears

Many administrative details received consideration. In recognition of the loyal support of members in years past, many of them for twenty and even thirty years, and of the conditions under which so many of them are now either entirely unemployed or if employed are unable to pay their dues, the Board has inaugurated a "suspended dues list." On this list are to be placed all members of the Society who on October 15 had not paid their 1932 dues and who write to the Secretary stating that they are unemployed or, if employed, are none the less unable to pay their dues. No publication of the list will be made and all memberships will be retained. Provision has also been made for these members to obtain such of the Society's publications as they wish at nominal prices. No action will be taken on those whose dues are thus suspended until after July 1, 1933. This procedure is in continuation of a program with respect to members in arrears which was developed at the July Board meeting.

Adjournment

The Board adjourned to meet in New York on January 16, 1933.

Alonzo J. Hammond, Choice of Nominating Committee

Meeting in Atlantic City on October 4, 1932, the Nominating Committee selected Alonzo J. Hammond as its official nominee for President in 1933. Previously, Mr. Hammond has served the Society both as Director and Vice-President. A brief account of his accomplishments, will appear in the December issue.

Three New Honorary Members

CANVASS OF BALLOTS for Honorary Members as provided by the Constitution took place during the Atlantic City meeting of the Board of Direction, resulting in the election of three eminent members of the Society; Lincoln Bush, of East Orange, N.J.; John E. Greiner of Baltimore, Md.; and Charles L. Strobel of Chicago, Ill.

All three men have previously served the Society on many occasions and in various capacities. Colonel Bush will be affectionately remembered throughout the country for his recent term as President in 1928, following previous services as Director, Vice-President, Treasurer, and member of important committees. Mr. Greiner also has held Society office, that of Director from 1915 to 1917. He has for many years been in consulting practice in various structural engineering fields, with offices in Baltimore.

Although the services of Mr. Strobel to the Society date back some years, he also is very well known and appreciated, especially by the older members. As far back as 1886 and 1894, he enjoyed terms as Director, later followed by one as Vice-President. His active practice centered in Chicago, Ill., but during recent years he has been retired.

In honoring these men, the Society greatly honors itself. Actual bestowal of these awards is expected to be one of the interesting features of the Annual Meeting next January.

Charles Warren Hunt—Minute Adopted by the Board of Direction, October 3, 1932

IN THE DEATH of Charles Warren Hunt on July 23, 1932, at the age of 74 years, the American Society of Civil Engineers lost its Secretary Emeritus.

In 1876, at the age of 18, he was graduated from New York University with the degree of C.E., and in 1909 he was honored by his alma mater with the degree of Doctor of Laws.

From graduation to 1892 he had a varied experience in the practice of his profession and served in a responsible capacity under outstanding engineers engaged in carrying out improvements in the metropolitan area. In 1892, eight years after his election to corporate membership, he became Assistant Secretary and Librarian of the American Society of Civil Engineers, and from this time up to his death he devoted himself solely and whole-heartedly to the upbuilding of the Society.

His efficiency, energy, and fidelity naturally led to his election as the ninth Secretary, on the retirement in 1895 of his predecessor, Francis Collingwood. At that time the headquarters of the Society were at 127 East 23d Street, and the Society had a membership of about 1,900, representing the growth of 43 years. The rapid increase which began with Dr. Hunt's incumbency necessitated the securing of larger quarters and was responsible for the move to 57th Street in 1897, and also for the enlargement of those quarters in 1905, when the membership had increased to 3,500. During the 25 years of his secretaryship and up to the time when failing health led Dr. Hunt to seek relief from his responsibility, the Society built up a membership of 9,400 and its publications were brought to their present high standard.

Dr. Hunt was one of the chief promoters of the merging of certain interests held in common with the Mechanical, Electrical, and Mining Engineers, which in 1917 resulted in sharing the library and the Engineering Building in West 39th Street. He had been especially interested in the library and had developed it until it was an exceedingly valuable asset of the Society.

Since his retirement in 1920, Dr. Hunt has served as Secretary Emeritus, his appointment as such having been made with the understanding that his long experience would be made use of as found necessary in the management of the Society.

His services to the Society may, therefore, be considered as extending over a period of 40 years, or one half of the Society's life. From the beginning of this connection it was recognized that Dr. Hunt possessed an unusually forceful character, an excellent technical background, broad learning, a genius for finance, a keen sense of the obligation of membership, and an unswerving devotion to the interests of the Society. It was recognized by those who knew him that the interests of the Society, as he saw them, were placed above every consideration of personal advantage or friendship, and that at all times and in all places he was ready to defend the Society against any proposal which, in his judgment, threatened a loss of dignity or prestige.

It was these qualities in its chief executive officer which were responsible for raising the standard of the American Society of Civil Engineers to its present high plane and for making its badge of membership a recognized evidence of qualification as a practicing engineer.

The Board of Direction places this minute in its records as a tribute to Charles Warren Hunt and his long and conspicuously valuable service in the upbuilding of the Society.

Official Nominees for 1933 Announced

THE SECOND BALLOT for official nominees for Vice-Presidents and Directors was canvassed at Headquarters on October 15, 1932. At its meeting on October 4, the Nominating Committee made its choice of a candidate for President. The following names, all Members Am. Soc. C.E., will therefore appear on the Official Ballot for officers for 1933:

For President, Alonzo J. Hammond, of Chicago, Ill.

For Vice-Presidents:

Zone II, Frank O. Dufour, of Philadelphia, Pa.
Zone III, Frank G. Jonah, of St. Louis, Mo.

For Directors:

District 1, J. P. H. Perry and James F. Sanborn, both of New York, N.Y. (two to be elected).
District 4, Henry J. Sherman, of Camden, N.J.
District 11, Ralph J. Reed, of Los Angeles, Calif.
District 14, W. W. Horner, of St. Louis, Mo.
District 15, Edward N. Noyes, of Dallas, Tex.

At least forty days before the Annual Meeting, a letter ballot will be mailed to every Corporate Member so that he may indicate his choice for each of these officers. This ballot will be canvassed one week before the Annual Meeting, at which the results will be announced. At that time the new officers will take up their duties.

John Ripley Freeman, 1855–1932

AN ILLUSTRIOUS LEADER of an engineering age ceased his labors on October 6 when John Ripley Freeman, Past-President and Honorary Member of the Society, died at his home in Providence, R.I., after an illness of two days. Only time can determine the tremendous contribution of Mr. Freeman to the civilization of his day.

In the engineering field, his name immediately suggests water supply and in the business world, industrial fire insurance. But actually, his interests overflowed all ordinary bounds—there was no branch of human endeavor that he touched without investigating it fully, sometimes exhaustively. His studies and reports on the water supplies for New York and San Francisco, to mention but a few, are classics. He did a vast amount of investigation on the hydraulics of the Great Lakes and on the lock and dam structures for the Panama Canal. Flood control was still another topic on which he was a recognized authority, as witnessed by his remarkable work on the Mississippi River in this country, the Yellow River in China, and the Po River in Italy. Earthquakes, with their fire-prevention and structural aspects, also claimed his attention. One of his latest efforts was a monumental volume, perhaps the greatest in the English language, on this subject. In addition, aeronautics, fire prevention, power development, and engineering education all received his extensive study.

With all these magnificent accomplishments, perhaps his greatest contribution was in the interest of hydraulic experimentation. This subject, which was to him something of a hobby, resulted in one of his foremost benefactions to human welfare. His tireless efforts over many years finally took concrete form in a National Hydraulic Laboratory, now operating in the U.S. Bureau of Standards. The same interest led him in 1924 to endow a generous number of traveling scholarships for hydraulic studies in Europe. His vision foresaw the inestimable value, particularly to American engineers and municipalities, of the broadest interchange of technical information. The Society alone, of several similar organizations, has already been privileged to send eight young men to Europe as Freeman Traveling Scholars.

No man could have lived so widely and so intensely as Mr. Freeman without being highly acclaimed by his fellow men. He was the recipient of numerous honorary doctor's degrees. He had the unique distinction of having enjoyed the presidency of the two great national societies of civil and mechanical engineers. In this Society alone he earned perhaps greater recognition than has been accorded to any other man. He was successively Director, Vice-President, and President. Twice he received the Norman Medal, the highest technical award in the Society, and once the J. James R. Croes Medal. Finally, and possibly most significant of all, he was made Honorary Member in 1930.

Characteristic of his high idealism and interest in his fellow engineers was one Society event during the last calendar year for which he was almost exclusively responsible. He conceived the idea of securing some notable Japanese engineer to visit America in the interests of better earthquake-resisting construction. Fortunately for him and all American engineers, his choice was the late Professor Kyoji Suyehiro, eminent Japanese authority. Ostensibly, Professor Suyehiro's visit a year ago was under the auspices of the Society; actually, it was Mr. Freeman's conception and his entire financial responsibility. The beneficial effects of this visit are beyond estimate at this time. Not content with the delightful visit itself, Mr. Freeman made it possible for the Society to publish and distribute the written notes covering these lectures.

Examples could be multiplied to emphasize the great accomplishments of this many-sided man. His industry and outstanding technical success will long be an incentive to every engineer. In his concept of the engineer's responsibility for human welfare and public service, he set a high and lasting ideal. The whole world will long be debtor to John R. Freeman.

Colonel Slattery Memorialized in Resolution of the Board of Direction

JOHN RODOLPH SLATTERY, director of the American Society of Civil Engineers, died suddenly at his home at Jackson Heights, Long Island, New York, on September twenty-third, nineteen hundred thirty-two at the age of 55 years. We, his fellow members of the Board of Direction assembled in meeting at Atlantic City, New Jersey, on the third day of October, nineteen hundred thirty-two, pause to record our loss and our profound sorrow at his passing.

It may truly be said that Colonel Slattery gave his life for his profession in his zeal, loyalty, and devotion to his work in the public service. He had a distinguished record as an engineer both in the army and in civilian life. While taken away in the midst of an active career, he leaves behind him an impressive record of accomplishments. He was an engineer of high character and integrity and a man of action.

In his death, the Society, the engineering profession, his many friends, and the community which he served so faithfully have sustained an irreparable loss. Our sincere sympathy goes out to his family and it is the desire of the Board of Direction that this expression of its esteem and affection for Colonel Slattery be entered upon its minutes and that a copy be engrossed and sent to his family.

Society Prizes for 1932

ANNOUNCEMENT of Society prizes for the current year was made when the Board of Direction at its October meeting approved the choice by the Committee on Prizes of the following:

Norman Medal—No award.

J. James R. Croes Medal—To David L. Yarnell and Floyd A. Nagler, Members Am. Soc. C.E., for their paper, "Effect of Turbulence on the Registration of Current Meters."

Thomas Fitch Rowland Prize—To Clifford Allen Betts, M. Am. Soc. C.E., for his paper, "Completion of Moffat Tunnel of Colorado."

James Laurie Prize—To Earl I. Brown, M. Am. Soc. C.E., for his paper "The Chesapeake and Delaware Canal."

Arthur M. Wellington Prize—To Fred Lavis, M. Am. Soc. C.E., for his paper "Highways as Elements of Transportation."

Collingwood Prize for Juniors—To A. R. C. Markl, Assoc. M. Am. Soc. C.E., for his paper "The Shannon Power Development in the Irish Free State."

The Committee on Prizes also went on record as recommending that Paper 1776, "Plastic Flow in Concrete Arches," by Lorenz G. Straub, Jun. Am. Soc. C.E., be given honorable mention, both for the merit in the paper itself and as an encouragement to Juniors to submit papers for publication in TRANSACTIONS. In this suggestion the Board also concurred.

These papers may be found in the 1931 TRANSACTIONS, Vol. 95. Presentations will take place as usual during the Annual Meeting next January.

Additions to Executive Committees of Divisions

ACCORDING TO the new provision of the Society By-laws, the Board of Direction has made its choice of appointees for members of the executive committees of the Technical Divisions, selected from the lists presented by the nominating committee of each Division. One to three names were presented to the Board for every vacancy. From these the following Corporate Members have been selected:

DIVISION	NEW MEMBER OF EXECUTIVE COMMITTEE
City Planning	Russell V. Black
Construction	Arthur C. Everham
Engineering-Economics and Finance	Daniel W. Mead
Highway	P. M. Tebbs
Power	James W. Rickey
Sanitary Engineering	Harry Edgar Miller
Structural	Eugene L. Macdonald
Surveying and Mapping	William Bowie
Waterways	William J. Barden

Having previously accepted the nominations, these men will therefore serve as the new members of the Division executive committees, each for five-year terms beginning in January 1933.

A Christmas Suggestion—For Ladies Only

THIS IS a confidential notice to the ladies of engineering families, whose ears it will reach through the devious methods known to all during the Christmas season. How often does the Christmas shopper think, "I don't mind buying the gift—if only I knew what he wanted."

If "he" needs a Society badge, it is a foregone conclusion that he wants it. These emblems, in spite of the fact that they are well guarded by safety devices, have the habit of becoming lost, misplaced, damaged in the wash, or injured by sundry other unexpected disasters. The badges are not very costly, only $5.00. And they make an ideal Christmas gift, a satisfaction to the giver and a real pleasure to the owner.

If the occasion is favorable, one of your chief Christmas problems is solved. It should be recalled, however, that members are not allowed to possess two badges, and if this Christmas gift is to replace a badge that has disappeared, it will be necessary for the member to file with the order for a new badge, a statement that the old one has been lost. The Society is glad to forward such a form on request to Headquarters.

It is a noteworthy fact that members usually wear the Society pin. The gift therefore has the virtue of utility as well as ornamentation. As these gifts are popular and as it takes approximately two weeks to have them engraved properly, orders should be at hand by December 1 to ensure delivery in ample time for Christmas.

Another Group of Memoirs Available

IN THE JUNE 1932 issue of CIVIL ENGINEERING appeared the last published list of memoirs in preprint form. Now a group of fifty additional memoirs are in type. Some of these have already appeared in Vol. 96 (1932) of TRANSACTIONS, and the rest will be included in Vol. 97 (1933), where they also will form a part of the permanent records of the Society. The list of men commemorated in these preprints follows:

Raymond Edmond Adams
William George Addis
Truman Heminway Aldrich
Julian Wilmot Alger
Samuel Pond Baird
Arthur Bernard Behrend
Fred Milton Bisbee
Louis David Blauvelt
Howard Edward Boardman
Gustave Maurice Braune
George Castleman Breckinridge
Hugh Brodie
Paul King Bunn
George Raymond Campbell
John Christian Valdemar Christensen
Alger Adams Conger
Floyd Gossett Dessery
Boyd Ehle
Charles Clement Elwell
Howard Richards Farnsworth
Frank Foster
James Hillhouse Fuertes
Emerson Warren Grant
James Clark Harding
Russell Theodore Hartman
Ferdinand Finney Harrington
Andrew Martin Jensen
Benjamin Oliver Johnson
William Henry Jones
Warren Byron Keim
Herbert Prescott Linnell
John Bruce Mailey
Alfred Stowe Mirick
Wesley Charnock Mock
Joseph Lincoln Murphy
Frederick Haynes Newell
Thomas Hartman Olds
Frederick George Ray
Abraham Moreau Reynolds
Earl Ivan Roberts
Coleman Sellers
Mitsugu Sengoku
William Francis Sheehan
Paul Bertram Spencer
William Aiken Starrett
Henry Allen Symonds
Arthur Webster Thompson
William Love Thompson
Max Ernst Robert Toltz
William Francis Tye
George Edward Wells
Gardner Stewart Williams
Frank Dennett Yost

Any of these biographical sketches of deceased members may be secured on request to Headquarters. No doubt a number of readers will find here the names of valued friends and admired colleagues and will wish to possess this final tribute to them by the Society of which they formed a worthy and still well remembered part.

More Student Prize Winners

IN THE SEPTEMBER issue appeared a list of winners of the student prizes awarded by Local Sections at commencement time. Since that list was published a number of additional names have been reported to Headquarters. After proper application and election, winners of these prizes are permitted to join the Society as Juniors, their dues for the first year being paid by the Local Section that gives the award. The following names should be added to those previously published:

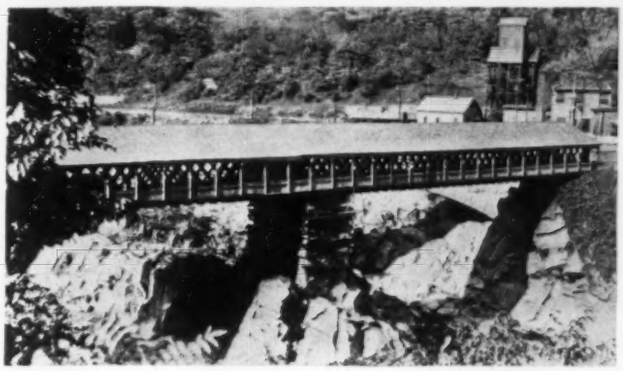
NAME OF STUDENT	COLLEGE	LOCAL SECTION GIVING AWARD
Harold C. MacSwain	Michigan State College	Detroit
Irving Lee Coffman	Kansas State College	Kansas
Homer Henry Harris	Louisiana State University	Louisiana
Maurice Carl Lipp	University of New Mexico	New Mexico
Thomas Laurence Hodges	North Carolina State College	North Carolina
Oscar Wilbur Kochtitzky	University of North Carolina	
Johnson L. Forbis	University of Oklahoma	Oklahoma
Dayton Williams	Oklahoma Agricultural and Mechanical College	
Harold A. Fidler	Drexel Institute	Philadelphia
Robert Frank Krishan	Drexel Institute	
Ellison C. Shute	Drexel Institute	
Egerton B. Sawtelle	Drexel Institute	

A Preview of Proceedings

Readers of PROCEEDINGS *should anticipate with pleasure the November issue, which will contain four unusually significant papers. The first will be a record or history of the use of timber for bridges by two eminent experts in this fast declining art. This very interesting paper will be followed by two separate yet related discussions of connections in structural steel. One of these deals with welded joints, and the other with riveted connections. The issue will be completed with a study of the factors affecting the design of stilling basins, based on a series of laboratory experiments.*

A HISTORY OF THE DEVELOPMENT OF WOODEN BRIDGES

IN THIS AGE of steel and concrete, research on wooden bridges may seem profitless; but certain members of the Society have insisted that there is material on the history of timber bridges, especially the distinctively American covered bridge, which should

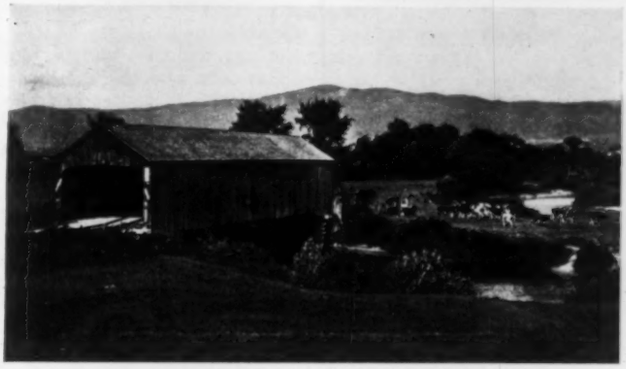


A TOWN LATTICE TRUSS OVER THE CONNECTICUT RIVER, AT BELLOWS FALLS, VT.
Built in 1840 and Removed in 1930; Over-All Length, 262 Ft.

be gathered and put on record. Furthermore, it has been emphasized that it is not yet too late to secure important data from the memory and experiences of men now living. The writers, Robert Fletcher and J. P. Snow, Members Am. Soc. C.E., being thus urged, have prepared this brief history, hoping that some of its readers may have other data which they can present to render the paper more complete.

There are few men better qualified to undertake such a task than Professor Fletcher, who is Director Emeritus of Thayer School at Dartmouth College, and Mr. Snow, who maintains consulting offices in Boston. In 1889 the late Theodore Cooper performed a valuable service to the profession in recording the history of the American railroad bridge to that date. Mr. Cooper's paper included a very condensed summary of the history of timber bridges as applied to the development of the railroad. The "History of the Development of Wooden Bridges," by Messrs. Fletcher and Snow, naturally is built on various sources, such as magazine articles, books, old encyclopedias, as well as on the material prepared by Mr. Cooper; but from a technological viewpoint this history is far more than a mere compilation of data secured by library research. The authors themselves were contemporaries of Theodore Cooper, as indeed they are active contemporaries of the engineers of this day.

The history of timber bridges covers the entire period from prehistoric times to the present. While acknowledging the fact that the era of the patented timber bridge in the United States is past, the authors point out that a proper knowledge of the principles of erecting timber bridges will always be necessary and useful in pioneer areas, of which there are still many on the face of the earth. Where timber is plentiful and transportation facilities are scarce, economic considerations will often dictate the erection of timber bridges within their feasible span lengths.



A TYPICAL NEW ENGLAND COVERED BRIDGE OF A TYPE FAST DISAPPEARING

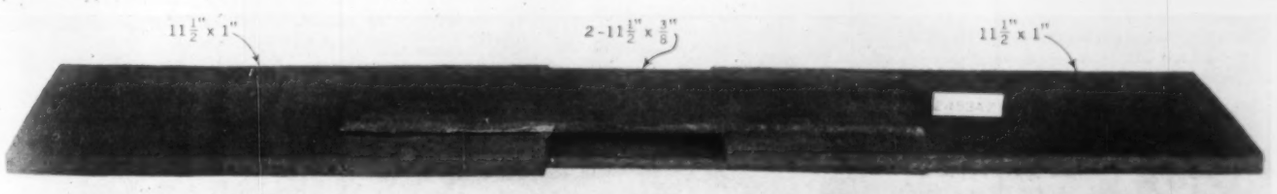
The paper contains an emphatic defense of the lattice-truss type of construction. Details of framing and instructions for the repair and maintenance of timber bridges form an important part of this work. Aside from these items, throughout the paper there is discussion of early American bridge designers and builders: Enoch Hale (1733); Timothy Palmer (1751–1821); Lewis Wernwag (1770–1843); Theodore Burr; Ithiel Town (1784–1844); Colonel Long; William Howe; Thomas W. and Caleb Pratt; Squire Whipple; and others. This feature supplies the framework of a record that will be ever more interesting to engineers as time goes on. The complete manuscript of a much more extensive study by the authors has been filed in the Engineering Societies Library in New York, for the guidance of those interested in further research.

In this connection the reader is referred to the page of Special Interest, in the front of this issue, where a bridge similar to some discussed in this paper is pictured.

DISTRIBUTION OF SHEAR IN WELDED CONNECTIONS

A CONCISE but adequate mathematical analysis of the distribution of shear stress along the length of longitudinal fillet welds is presented in the paper by Henry W. Troelsch, M. Am. Soc. C.E. The analysis is made for welds that are continuous over the entire length of the lap joint, and the author claims that the theory will apply also to intermittent welds. According to him, the method can also be used to approximate the distribution of shear in a line of rivets, if the deformation of the slip of each rivet is assumed to be proportional to its shear. Three illustrative examples at the end of the paper complete the demonstration.

Two of Mr. Troelsch's conclusions are that the distribution of shear is more nearly uniform in a short joint than in a relatively long one, and that beyond a certain increase in the length of the weld no appreciable reduction in the maximum shear will result from further increases in length.



LAP-WELDED TEST SPECIMEN, 0⅜ BY 40-IN. WELD, ULTIMATE LOAD 459,000 LB.
"Did All Parts of This Weld Carry an Equal Share of the Shear or Were Some Parts More Highly Stressed Than Others?"

WORK OF RIVETS IN RIVETED JOINTS

IN A SENSE paralleling the work of Mr. Troelsch, the paper by A. Hrennikoff, Esq., deals with riveted, as opposed to welded, joints. Although the paper is brief compared to most PROCEEDINGS papers, it is divided logically into three parts: (1) a qualitative study, with some observations on conventional design methods; (2) the derivation of formulas; and (3) the application of formulas to numerical examples.

What happens to a force when it passes through a riveted joint from one member to another? If Mr. Hrennikoff's dissertation on this subject is philosophical, it will have its justification in the number of more complicated questions that arise from the basic one. To divide the total shear in a joint by the allowable shear in a rivet that has not yet been manufactured, and thus to determine the number of rivets in the joint, has been a simple design expedient. But will this "standard practice" suffice forever, simply because the failure of structures has not yet been attributed to it?

There is much debatable material in this short and interesting paper, as may be indicated by a simple declaration of the author's conclusions: first, the standard practice of dividing the force proportionally to the shearing area of the rivets and disregarding the deformation of the plate is very inaccurate; second, actually the force acting on a riveted joint is not distributed equally among the rivets, for the larger proportion of the total work is done by the outer rivets; third, the proportion of total work in the outer rivets increases as the pitch and diameter of the rivets increase, and as the cross section of the plate decreases; and fourth, if there are many rivets in a longitudinal row, the inner rivets are inefficient and an increase in the number does not improve appreciably the efficiency of the joints.

STUDY OF STILLING BASIN DESIGN

DRAWING on his experience in the Hydraulic Laboratory of the University of Iowa in 1928, C. Maxwell Stanley, Jun. Am. Soc. C.E., has prepared an interesting study of the factors affecting the design of stilling basins. The paper classifies stilling basins in five distinct types and gives the characteristics of each. The writer has reduced his observations to computed ratios of depths (D_w) of water at the weir required for smooth flow over the weir to depths (D_j) of water required in the basin for the formation of a hydraulic jump. He has plotted his data in the form of curves, with values of $\frac{L}{D_w}$ as abscissas (L = length of weir), and discusses the relative merits of the types of stilling basins by the location of the various plottings with relation to a smooth curve.

A more complete form of the paper, with all the laboratory data classified and tabulated, has been placed on file in the Engineering Societies Library in New York for reference. It is felt, however, that all the essential information necessary for purposes of study and discussion has been included in the paper as it is being published.

Five items in Mr. Stanley's summary of interpretations are: "(1) The action of the stilling basin is closely connected to the phenomena of hydraulic jumps. (2) The ratios of $\frac{D_w}{D_j}$ and $\frac{L}{D_w}$ serve satisfactorily to classify the action of a stilling basin into the five types described. (3) For satisfactory action of a stilling basin, the ratio $\frac{D_w}{D_j}$ must be greater than 0.85. (4) For any value of $\frac{D_w}{D_j}$ greater than 0.85, there is a corresponding minimum value of the ratio $\frac{L}{D_w}$ that determines the minimum proportions of a stilling basin for satisfactory action. As the ratio $\frac{D_w}{D_j}$ increases, the ratio $\frac{L}{D_w}$ decreases. (5) Increasing the length of a basin to obtain a ratio of $\frac{L}{D_w}$ greater than this minimum value does not improve the action. The ratio $\frac{L}{D_w}$ need never exceed 4.0 or 5.0, depending on the ratio of $\frac{D_w}{D_j}$ and on the design of the dam.

News of Local Sections

CENTRAL OHIO SECTION

There were 22 in attendance at the regular monthly meeting of the Central Ohio Section, held in Columbus on September 22. After luncheon various business matters were attended to. Those present then enjoyed a talk given by John R. MacGregor, of the Eagle-Pitcher Lead Company, whose subject was "Paint Phenomena—Changes Occurring in Paint Film."

CLEVELAND SECTION

A dinner meeting of the Cleveland Section was held at the Akron City Club, Akron, Ohio, on October 4. Among the speakers were J. Ray Stine, Principal of Central High School, who presented an interesting film describing the Akron water supply system, and M. P. Tucker, Superintendent of the Akron Water Works. The latter explained more in detail the proposed plans for development of the water supply system.

GEORGIA SECTION

The August meeting of the Georgia Section was held in Atlanta on August 8, with 28 members and guests in attendance. Included in the business session was a discussion of the present status of the Atlanta sewer project, and the appointment of a special Public Works Development Committee was announced from the chair. The address for the day was given by Arthur Stokes, secretary of the Atlanta Realty Board.

LOS ANGELES SECTION

After a summer recess, the Los Angeles Section resumed their monthly sessions at a dinner meeting, held September 14 at the Engineers' Club. Approximately 110 members and guests were present. An interesting paper entitled "Application of Water Control in Concrete Pavement Construction" was presented by A. E. Burt, Construction Engineer with the Los Angeles County Road Department; and F. A. Schilling, President of the Desert Forum, Pasadena, Calif., gave an illustrated talk on the life, works, mode of living, arts, and legends of the prehistoric Indians of Arizona and New Mexico.

METROPOLITAN SECTION

With its meeting of October 19, the Metropolitan Section began a new year of activity. This session, which was held in the Engineering Societies Building, in New York, was attended by over 300 interested members. Herbert S. Crocker, President of the Society, addressed the Section briefly, recalling that he was a member of three Local Sections and was the first member to join the Metropolitan Section.

The topic of the evening was the purpose and use of the recently completed Inland Terminal No. 1 of the Port of New York Authority. The main paper was presented by John C. Evans, Terminal Engineer, who illustrated his address with lantern slides and moving pictures. These made it easy to visualize this huge 15-story truck terminal for handling less-than-carload lots of railroad freight. This paper was amplified by discussions by Col. P. L Gerhardt, C. W. Rau, and J. A. Hoffman. At the close of the meeting refreshments were served.

NORTH CAROLINA SECTION

On September 20, Prof. Harold C. Bird, of Duke University, Durham, N.C., was nominated secretary-treasurer of the North Carolina Section of the Society to fill the position recently vacated by the resignation of Thorndike Saville.

PORTLAND (ORE.) SECTION

At the meeting called to order on August 30 there were 44 present, the largest attendance of the year except at the annual meeting. The report of the Committee on Development of the

Columbia River, was read by J. C. Stevens, chairman of the committee. The principal feature of the occasion was an address by Charles P. Craig, vice-president and executive director of the Great Lakes-St. Lawrence Waterway Association, who discussed the subject of the St. Lawrence Waterway improvements. The meeting was followed by a buffet lunch and social hour.

Student Chapter News

RHODE ISLAND STATE COLLEGE

There were 26 in attendance at the meeting of the Rhode Island State College Student Chapter, held in Kingston, R.I., on October 4. The contact member of the Chapter, James L. Murray, Highway Commissioner of Warwick, spoke briefly on the aims and purposes of the organization. Ernest J. Pauls, of the class of 1933, ably delivered the lantern lecture furnished by the Society on the "Muscle Shoals Hydro-Electric Development." The lecture was well received.

Appointments of Society Representatives

RALPH BUDD, M. Am. Soc. C.E., has accepted an appointment as the Society's representative on the Hoover Medal Board of Award.

J. VIPOND DAVIES and HARRISON P. EDDY, Members Am. Soc. C.E., and CHARLES F. LOWETH, Past-President Am. Soc. C.E., have been appointed by the President as the Society's representatives on the Engineers' Council for Professional Development.

GEORGE T. SEABURY, Secretary Am. Soc. C.E., has accepted an appointment as Society representative on the Division of Engineering and Industrial Research of the National Research Council for the three-year term, July 1932–July 1935. The secretaries of the other three Founder Societies are similarly members of this division.

American Engineering Council

National representative of 27 engineering societies, with a constituent membership of 62,000 professional engineers, reports civil engineering news of the Federal Government

RECONSTRUCTION FINANCE CORPORATION MOVES TO EXPEDITE SELF-LIQUIDATING LOANS

The Reconstruction Finance Corporation has added an engineer member to each of its 32 Regional Advisory Committees. It is expected that the appointment of an engineer on these committees will do much toward expediting the application for loans, especially for small projects. The full possibilities in this field have not been properly developed. The engineer members of these committees will be in a position to advise as to the character of projects that can be financed and the procedure necessary in order to obtain prompt consideration by the Reconstruction Finance Corporation.

These engineers will serve without compensation, as do the other members of the Advisory Committees; however, they will be reimbursed for any expenses incurred. They will not render any engineering services to applicants; hence they will not in any way supplant the services of private engineers engaged in preparing applications or in the actual construction of a project. It is the policy of the Corporation to require all applicants, through their engineers, to submit the necessary engineering information.

EMERGENCY FUNDS FOR FEDERAL CONSTRUCTION MADE AVAILABLE

The Emergency Relief and Construction Act of 1932 provided that before funds could be made available for emergency construction, as provided under Title III of the act, it would be necessary for the Secretary of the Treasury to certify that the necessary funds were on hand or easily obtainable. Information transmitted by the Secretary to the President under date of September 9 eliminated this necessity and made possible a concentrated expedition of the work provided for under the act.

In connection with the appropriations for emergency construction, the Comptroller General has ruled that the 10 per cent reduction specified in the Economy Act must be applied to these items. Of the net amount of $90,000,000 allocated to the construction of Federal buildings outside the District of Columbia, announcement has already been made of projects to cost almost $85,000,000. These include 41 costing more than $300,000 each, 142 costing between $300,000 and $100,000 each, and 227 costing less than $100,000. In accordance with the policy pursued by the Supervising Architect's office, the architectural and engineering work on many of these projects is being handled by private firms.

On September 13, the War Department announced that over $40,000,000 in appropriations for flood-control and river and harbor projects, as authorized in the Emergency Relief Act, had been approved by Col. Frederick H. Payne, Assistant Secretary of War. Approximately $4,000,000 of the authorized appropriation is being held in reserve for future allotment and for contingencies.

The Secretary of Agriculture has approved the apportionment of $3,000,000 in emergency forest highway funds to be expended in 34 states and territories. The building of new highways in the National Forests will be rushed, according to a statement issued by the department on September 10.

MOVE UNDER WAY TO STIMULATE INDUSTRIAL REHABILITATION

Under the auspices of the Banking and Industrial Committee, a National Committee on Industrial Rehabilitation has been formed under the chairmanship of A. W. Robertson, Chairman of the Board of the Westinghouse Electric and Manufacturing Corporation. Subcommittees are to be formed in the various Federal Reserve Districts for the purpose of encouraging industries to give consideration to the modernization of their plants and equipment by replacing obsolete machinery and by initiating repairs or improvements, and also to review their stocks on hand with the idea of replenishing at least those that are abnormally low.

HOME LOAN BANK ORGANIZATION COMPLETED

Announcement has been made of the boards of directors and officers for the 12 District Home Loan Banks. A conference of the members of the Home Loan Bank Board and the executives of the 12 regional banks met in Washington on October 5 to consider the phases of the permanent and emergency functions of the organization, which is to be in full operation by October 15. It is our understanding that the personnel of each district Home Loan Board will include an appraisal section in order to determine the fair value of properties offered as security for loans.

REORGANIZATION OF FEDERAL GOVERNMENT

President Hoover stated orally on September 13 that he would lay before Congress for the first time at its forthcoming session in December a complete plan for the reorganization of the Federal Government. He has directed the Director of the Budget to set up the necessary staff to investigate reorganization projects and prepare executive orders to carry them out. It is hoped that duplication of effort and overlapping of duties by the various executive branches of the Government can be eliminated, with resultant economies.

DUTIES TRANSFERRED TO CIVIL SERVICE COMMISSION

Under authority of the Federal Economy Act of 1932, which enables the President to consolidate certain governmental functions in the interest of economy, the functions of the Personnel Classification Board have been transferred to a new division of the Civil Service Commission, to be known as the Division of Personnel Classification, according to a recent announcement of the Civil Service Commission. One of the duties of the new division will be that of writing class specifications, as provided for in the Classification Act.

FEDERAL POWER COMMISSION RELEASES REPORT

On September 18 the Federal Power Commission made public its report on the Investigation of Holding Companies and Their Relations with Hydro-Electric Power Plants Licensed by the Commission. The report gives details of the operations in the electric utility field of certain large groups, each of which controls one or more licensees.

ITEMS OF INTEREST

Engineering Events in Brief

Civil Engineering for December

IN THE DECEMBER issue of CIVIL ENGINEERING will be found articles prepared from all the papers delivered at the Atlantic City Meeting of the Society. The subjects of these papers are generally related to problems of economies and planning. At the general session and at the sessions of five of the Society's Technical Divisions the speakers presented papers on the new passenger-station facilities of the Pennsylvania Railroad in Philadelphia; regional planning in the Philadelphia Tri-State District; sewage disposal problems of the Atlantic seaboard communities in New Jersey; a joint trunk sewer for the drainage area of the Hackensack River in New Jersey; refuse incinerators in Washington, D.C.; water supply and waste disposal problems in Pennsylvania and Delaware; traffic control for city streets and state highways; city planning; and the financing of public works. This wide range of subjects—a wealth of current engineering thought—will be covered in the score of articles to appear in the December issue.

In this issue, also, will be found the index to Volume 2 of CIVIL ENGINEERING, covering the 12 issues that will have appeared during 1932. With the addition of various items on the current activities of the Society, the December issue will be one that members and readers can look forward to with decided interest.

Boston Keeps Unemployed Engineers Busy

ACCORDING to the latest report, that of October 7, of the Emergency Planning and Relief Bureau, Inc., of Boston, 319 unemployed engineers were given work as a result of its efforts. This organization is composed of the nine local sections of national engineering societies and four local societies. However, the Bureau has placed more non-members of these groups than members. It is composed of an Architectural Division and an Engineering Division, which have worked in close cooperation. Out of 1,262 applicants, 376 have been directly employed by the Bureau and positions have been obtained for 171 others. The peak of the employment was last April, when the payroll for 240 men was $3,600 per week.

Because of limited funds and the great number requiring help, only the most needy and deserving cases have been aided. Quarters and furniture were furnished without cost to the Bureau on two floors of the Edison Building on Tremont Street. By close budgetary control of available funds, more than 96 cents out of each dollar received has been put into the payroll.

The report, which is signed by William Stanley Parker, president of the Relief Bureau, states that, without competing in any way with the work of architectural and engineering firms, the Bureau has assembled a classified mass of information. Long needed maps, for which funds have never been available, have been made for state institutions. Over $11,000 has been spent on these, for work which would have required about $56,000 of appropriation. Housing conditions, valuations, and rehabilitations have been studied. Plans have been prepared showing streets and properties by types, which will be turned over to the City Planning Board. Facts, otherwise unavailable, have been tabulated and graphed. More information has been developed by the Bureau in connection with the metropolitan area than has ever before been assembled in one place. All this work has been done under competent direction. The community has the benefit of technical work for which contributions of over $75,000 have been expended to date.

The Bureau is well along in its work of assembling basic data for a metropolitan study and plan, a project on which Philadelphia spent about $750,000. It has supplied men to aid in the organization of the Job Finding Campaign and has received substantial contributions from the Allocation Committee of the United Unemployment Relief Campaign.

Faced with the probability of a continued shortage of employment through the coming winter months, and to conserve funds, the Bureau is finding it necessary to reduce the rate of expenditure. The number of employees was reduced to about 170, and the men were put on part time during the summer. The average weekly pay, which was originally $15, has now been reduced to about $9. Even on this basis, however, the funds of the Bureau are getting low, and the present rate of pay is inadequate for cold weather living expenses. At the same time, the Bureau's opportunity for useful work has never been so great as it is now.

Bridge History Revealed in Unusual Exhibition

IN CONNECTION with the opening of the Lorain-Carnegie Viaduct across the Cuyahoga Valley in Cleveland, Ohio, Wilbur J. Watson, M. Am. Soc. C.E., consulting engineer in charge of design and construction, has arranged an exhibit at the Cleveland Public Library that is of particular interest to bridge engineers. It consists of three parts: first, a collection of about 200 photographs illustrating the development of the art of bridge construction from the earliest times to the present, arranged chronologically; second, a collection of etchings, old lithographs, and such of bridges; and third, a collection of books on bridges, comprising many old and rare volumes.

All this material has been loaned from Dr. Watson's own collection. Particularly interesting are the volumes published in the eighteenth century in France, illustrating the work of Peronnet and others, and profusely illustrated with beautifully executed copper-plate engravings. The exhibit probably will be open until January 1, 1933. While it has a popular appeal it has also a peculiar significance for engineers, which is felt to warrant inspection and study. Admission is free.

Scholarships Awarded to Juniors

INFORMATION has been received of the award of an American-German Student Exchange Scholarship to Elmer J. Sperling, Jun. Am. Soc. C.E., for the study of hydraulic engineering in Germany. Mr. Sperling will enter the Fridericiana Technische Hochschule at Karlsruhe at the beginning of the 1932–1933 school year.

Another Junior in the Society, D. K. van Ingen, Jr., has been awarded a Strathcona Fellowship in Transportation at Yale University. He has now begun his work in New Haven.

On the Art of Train Dodging

By E. B. MENUEZ

VALUATION ENGINEER, NEW YORK CENTRAL RAILWAY COMPANY

EVERY RAILROAD engineer of any considerable experience presumably has had a number of novel and perhaps hazardous experiences. In retrospect, some of these appear more amusing than dangerous. Such a one happened to me many years ago.

It occurred on a single-track railroad in the Middle West, the Baltimore and Ohio Southwestern. The characters involved were an Irish contractor who was getting information about some proposed railroad work and I, the railway engineer. Also there was a speeder such as was used for transporting men and light material along the road—not the modern gasoline type, which can make fairly good time, but one of the older two-man, hand-operated affairs. I knew there was an express flyer following us, but I was assured by one of the railroad agents that I would have

ample time to make the next station in safety. So we started out. The grade was downhill and somewhat easy going, although not at all straight. I was not worried, but I took the precaution of warning the contractor to keep an eye to the back while I watched out in front.

All went well and we were enjoying a splendid ride, particularly the contractor, who insisted on regaling me with interesting stories, to the severe detriment, as it later appeared, of his more important responsibilities. For myself, I was in the front of the speeder where the noise of the gears almost deafened me, and utterly oblivious of any impending emergency.

A Choice of Evils

We were just emerging from a 6-deg. curve when one of the most interesting stories was rudely interrupted by three sharp blasts from the locomotive of the express. A hasty glance showed the fast train almost on top of us. Yelling to the contractor to jump for his life, I took just one hasty glance at the prospect for myself. The right-of-way had changed from cut to a high fill. On the one side it was held by a retaining wall, beyond which was a sheer drop of 30 ft. to a river. On the other side there was a tangled thicket of briar bushes. Instinctively, I chose the river side, while the contractor took the other.

With more haste than grace I rolled off the speeder onto the gravel ballast and finally came to rest on the edge of the retaining wall above the river. The train thundered by but came to a quick stop; the air hose in front of the engine had been cut by the wreck of the speeder.

Reckoning Up the Damage

As the train started to back up I arose to find myself only bruised. My next thought was of the contractor, and well he needed it. There he was, gingerly picking himself out of the bramble bushes, which had left him much the worse for wear. His clothes had been torn off, even to his undershirt, and the briars had not dealt any too tenderly with his person. In the interest of decency and decorum, we bribed the Pullman porters to furnish us with a couple of blankets. Thus we rode to Cincinnati, where he had to outfit himself from the ground up.

I have forgotten whether or not he ever got the contract.

Library has Manual Available

In 1927 the Engineering Foundation published a "Manual of the Endurance of Metals Under Repeated Stress," in which the views and data on the fatigue of metals were summarized for designers, inspectors, and testing engineers. The Engineering Societies Library, 29 West 39th Street, New York, has acquired the remaining stock of this work and will be glad to send a copy to anyone interested, on receipt of 25 cents to cover shipping costs.

John Fritz Medal Awarded

Established in 1902 by the professional friends and associates of the late John Fritz, Hon. M. Am. Soc. C.E., the John Fritz gold medal is awarded for notable scientific or industrial achievement. The medal is awarded not oftener than once a year and there is no restriction as to the nationality or sex of the recipient.

It has been announced that the award for 1933 will be made to Daniel C. Jackling, "for notable industrial achievement in initiating mass production of copper from low grade ores, through application of engineering pinciples." The activities of Mr. Jackling have been carried on in the mining regions of the West, particularly in Utah, Arizona, Nevada, and New Mexico.

NEWS OF ENGINEERS

From Correspondence and Society Files

Reeves J. Newsom, who was formerly vice-president, general manager, and chief engineer of the Community Water Service Company of New York City, has been promoted to the position of executive vice-president of the company.

Donald Mills, formerly of Sewickley, Pa., has become connected with the U.S. Engineer Office, Memphis, Tenn., as an assistant inspector. In this capacity he is engaged on the U.S. Dredge "Potter."

Rex P. Johnson has entered the employ of the Rust Engineering Company of Pittsburgh as Chief Draftsman in the Industrial Building Department.

Allen Joseph Negrotto, until recently an engineer with J. W. Billingsley of New Orleans, La., has now accepted a position as Designing Engineer with the Board of Commissioners for the Port of New Orleans.

T. F. McGarey, Jr., has been transferred to the Delaware River District Office of the Shell Eastern Petroleum Products, Inc., in Philadelphia.

C. A. Campbell has resigned his position as Superintendent of Streets of Great Barrington, Mass., to become Assistant Highway Engineer of the Bureau of Maintenance of Connecticut State Highways, with headquarters in Middletown, Conn.

W. D. Shannon is now president of a newly formed organization, Shannon Engineering Company, with offices in Seattle, Wash. Mr. Shannon was for many years general superintendent for Stone and Webster in their Seattle district.

H. Spencer Merz, previously Assistant Engineer with Pearse, Greeley, and Hansen, Rockford, Ill., is now Assistant Engineer for the Sanitary District of Rockford, Rockford, Ill.

L. Boyd Mercer, who has been South American representative for the Jones-Hettelsater Construction Company of Kansas City, has returned from Buenos Aires and is now in the Kansas City office of the same organization.

Joseph M. Cooke, formerly Steel Detailer for the Fireproof Products Company of Charleston, W. Va., has now become Junior Engineer in the U.S. Engineer Department, Charleston-Kanawha, W. Va.

F. E. Fahy has been promoted from Instructor to Assistant Professor of Civil Engineering at Antioch College, Yellow Springs, Ohio.

Harry A. Markle, Jr., has formed an association to be known as Markle and Gilbert, Architects and Engineers, with offices at 1 South Whitehall Avenue, Allentown, Pa. Formerly Mr. Markle was a student engineer with the Lehigh Structural Steel Company of the same city.

W. C. Muldrow, former manager of the Columbia Irrigation District at Kennewick, Wash., is now engineering manager and secretary of the Sunnyside Irrigation District, Benton City, Wash.

John J. Ledbetter, Jr., formerly Assistant Engineer with the American Section of the International Water Commission of San Benito, Tex., has accepted an appointment as Assistant Engineer of the International Boundary Commission.

A. F. Di Domenico has resigned his position as Principal Assistant Engineer of the Water Main Extensions, Sanitary Division of the Baltimore County Metropolitan District, Towson, Md., and is now connected with the Bureau of Water Supply of Baltimore.

Herman Miller has resigned his position as superintendent of the Young Steel Pile Company of New York City and is now superintendent of I. B. Miller Inc., Engineers and Contractors of the same city.

H. L. Fruechtenicht, Jr. has taken a position as Gas Engineer with the Consumers Power Company of Mt. Pleasant, Mich. Formerly he was Field Engineer for the Frick-Reid Supply Corporation of Pittsburgh.

Gordon L. Long is now employed by the Bridge Department of the State of California Division of Highways as resident engineer on bridge construction. He was formerly Junior Hydraulic Engineer, State Division of Water Resources, Ukiah, Calif.

Finley B. Laverty, formerly a civil engineer in the Hydrographic Department of the Los Angeles County Flood Control District, is now employed in the design department of the same organization.

E. A. Silagi has entered the employ of the China United Engineering Corporation of Shanghai, China. He was previously connected with the Pacific Commercial Company of Manila, P.I.

Herbert F. Anderson, formerly an engineering computer for the Big Four Railway of Cincinnati, Ohio, has accepted a position with the F. A. Klenk Company of the same city.

Changes in Membership Grades

Additions, Transfers, Reinstatements, Deaths, and Resignations

From September 10 to October 8, 1932

New Honorary Members

Bush, Lincoln (Elected M., Oct. 4, '05; Hon. M., Oct. 3, '32). Cons. Engr., 345 Springdale Ave., East Orange, N.J.

Greiner, John Edwin (Elected M., June 4, '90; Hon. M., Oct. 3, '32). Cons. Engr., 1201 St. Paul St., Baltimore, Md.

Strobel, Charles Louis (Elected M., Dec. 3, '79; Hon. M., Oct. 3, '32). 1644 Monadnock Blk., Chicago, Ill.

Additions to Membership

Aren, Armin Conrad Henry (M. '32), Asst. Structural Engr., Div. of Highways, Dept. of Public Works (Res., 3452 Harlem Pl.), Cincinnati, Ohio.

Beall, Marsh Flagg (Jun. '32), 716 Union Ave., S.E., Grand Rapids, Mich.

Beatty, Blake Elwood (Assoc. M. '31), (Russell & Beatty) (Res., 2830 San Marino St.), Los Angeles, Calif.

Carroll, William Joseph (Assoc. M. '32), Div. Engr., The Bituminous Service Co., Inc., West Chester (Res., 422 East Hector St., Conshohocken), Pa.

Clark, Roy (Jun. '32), Flowery Branch, Ga.

Cooper, Charles Samuel (Jun. '32), Asst. in Chg. of Drafting Room, Div. of Survey and Design, Bureau of Highways (Res., 183 Ocean Parkway), Brooklyn, N.Y.

Donato, Dante Frank Joseph (Jun. '32), 1816 White Plains Ave., New York, N.Y.

Ela, Mohamed Mahmond Aboul (Assoc. M. '32), Asst. Engr., Sewerage Dept., Alexandria Municipality; 23 Rue Rassafa, Alexandria, Egypt.

Gaines, Alfred Wallace (M. '32), Constr. Engr., Geo. W. Condon Co., Omaha, Nebr. (Res., 107 South 7th St., Council Bluffs, Iowa).

Guernsey, Curtis Harold (Assoc. M. '32), County-City Engr., Court House, Cherokee, Okla.

Hickman, Harold Clarence (Jun. '32), Federal Highway Engr., Division of Management, Bureau of Public Roads, Washington, D.C.

Kesting, Bernard George (Jun. '32), Asst. Engr., State Highway Dept. (Res., 173 East Broadway), Toledo, Ohio.

Liebsch, Joseph Peter Harry (Assoc. M. '32), Structural Designer and Checker, Bridge Div., Bureau of Eng. and Surveys (Res., 6815 North Gratz St.), Philadelphia, Pa.

Mims, Staley Wood (Jun. '32), Field Asst. to Res. Engr., State Highway Dept. (Res., East 3d St.), Crockett, Tex.

Parker, Thomas Clair (Assoc. M. '32), Associate Engr., National Park Service, Zion National Park, Springdale, Utah.

Pearson, Theo Porter (Jun. '32), 300 Southwest North River Drive, Miami, Fla.

Pedigo, James Alan (Jun. '32), Bridge Designer, Los Angeles County Road Dept., 1202 Hall of Records, Los Angeles, Calif.

Smirnoff, Valentine Fedor (Jun. '32), 1012 Tenth St., Santa Monica, Calif.

Sours, Harold Glenn (Assoc. M. '32), Res. Engr., State Highway Dept., County Engr., Summit County, County Engr's Office, Akron, Ohio.

Stewart, Robert Shortridge (Jun. '32), 2275 East 60th St., Seattle, Wash.

Walsh, Walter Vincent (Assoc. M. '32), Vice-Pres. and Treas., John H. Eisele Co., Inc., 18 East 41st St., New York, N.Y.

Membership Transfers

Birke, Hakan Daniel (Jun. '30; Assoc. M. '32), care W. Danielsson, Orkelljunga, Sweden.

Hilton, Joseph Kennicott (Assoc. M. '23; M. '32), Div. Maintenance Engr., State Highway Comm. (Res., 709 First Ave.), Clarion, Ohio.

Rapp, George Marvin (Jun. '23; Assoc. M. July '32), Asst. Engr., The Port of New York Authority, New York, N.Y. (Res., 75 Gordonhurst Ave., Montclair, N.J.).

Smith, Waldo Edward (Jun. '27; Assoc. M. '32), Asst. Prof., Civ. Eng., North Dakota State Coll. (Res. 717 Tenth Ave., North), Fargo, N.D.

Reinstatements

Piatt, William McKinney, M., reinstated Sept. 27, '32.

Resignations

Roberts, Harry Ashton, Assoc. M., resigned Sept. 23, '32.

Simpson, Charles Randolph, Assoc. M., resigned Oct. 6, '32.

Deaths

Belknap, Francis Wheelwright. Elected Assoc. M., Feb. 1, 1905, M., June 24, 1914; died Sept. 22, 1932.

Brockway, James McCormick. Elected Jun., Mar. 11, 1929; died Sept. 14, 1932.

Butts, Wendell Morris. Elected Assoc. M., Oct. 14, 1919; died Sept. 23, 1932.

Conard, Winfield Walker. Elected M., June 6, 1921; date of death unknown.

Faris, Robert Lee. Elected M., Mar. 14, 1916; died Oct. 5, 1932.

Freeman, John Ripley. Elected Jun., 1882, M., 1889, Hon. M., 1930; Director, 1896–1898, Vice-Pres. 1902–1903, Pres. 1922; died Oct. 6, 1932.

Hirst, Arthur Rasco. Elected M., Oct. 15, 1925; died Sept. 17, 1932.

Ranney, Willis. Elected Assoc. M., July 9, 1912, M., June 12, 1917; died July 16, 1932.

Roberts, Victor Jamison. Elected Assoc. M., June 7, 1925; died Sept. 8, 1932.

Slattery, John Rodolph. Elected M., Oct. 11, 1920; died Sept. 23, 1932.

Spencer, Theodore Nelson. Elected Assoc. M., Sept. 5, 1900, M. Mar. 4, 1914; died Sept. 9, 1932.

TOTAL MEMBERSHIP AS OF OCTOBER 8, 1932

Members	5,813
Associate Members	6,276
Corporate Members	12,089
Honorary Members	19
Juniors	2,832
Affiliates	118
Fellows	5
Total	15,063

Men Available

These items are from information furnished by the Engineering Societies Employment Service with offices in Chicago, New York, and San Francisco. The Service is available to all members of the contributing societies. A complete statement of the procedure, the location of offices, and the fees is to be found on page 97 of the 1932 Year Book of the Society. Unless otherwise noted, replies should be addressed to the key number, Engineering Societies Employment Service, 31 West 39th Street, New York, N.Y.

Construction

Construction Superintendent and Engineer; Assoc. M. Am. Soc. C.E.; 20 years experience on construction of school and monumental buildings, heavy concrete construction, bridges, foundation work. Recently specialized in foundation and bridge work, including foundations for large buildings and bridge piers. Thoroughly understands supervision of heavy equipment, pile driving, cofferdam, concrete work, and general construction. D-261.

Field Engineer; Assoc. M. Am. Soc. C.E.; 29; graduate; 3 years responsible position with public utility on conduit construction; 5½ years experience on highways, bridges, buildings, and surveying. Good fieldman for contractor, architect, or utility company on any type of construction. Location anywhere. D-1586.

Design

Civil Engineer; Assoc. M. Am. Soc. C.E.; 37; married; graduate; state licenses; 10 years experience surveying, design, and construction. Railroad track, yards, and structures; highways and highway structures; harbor projects; tall buildings; parkways and parkway structures. Completely familiar with design of rigid frame bridges. Available immediately. D-1496.

Civil Engineer; Assoc. M. Am. Soc. C.E.; 30; single; B.S. in C.E.; 8 years experience in the design of railroad and highway bridges. Desires position with an engineering organization or is willing to make start in an allied field. Location immaterial. Available immediately. D-1544

Designer; Assoc. M. Am. Soc. C.E.; 37; married; member A.W.W.A.; experienced in water works, sewage treatment plants, incinerators; 12 years experience. Associated with leading sanitary engineers: 6 years field; 6 years drafting and design; 5 years responsible charge of work. Active student with complete library and files. Can take charge of design if required C-6422.

Civil Engineer; Jun. Am. Soc. C.E.; 26; single; graduate of Ohio State University; 2 years experience in structural steel fabricating, design, and detailing; 2 years varied experience on construction of buildings. Prefers design, teaching, or research work, but any position will be acceptable. Available immediately. D-1563.

EXECUTIVE

STRUCTURAL ENGINEER; Assoc. M. Am. Soc. C.E.; 35; married; M.S., University of Illinois. Thorough experience in design of buildings, rigid-frame bridges, subways, concrete, and structural steel. Aptitude for analytical work. Wide theoretical and practical knowledge of analysis of continuous frames. Experience with steel company, college, architect, consulting engineer, association, subway design bureau. D-1507.

CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; 30 years experience, chiefly specializing in food markets, cold storage, refrigeration; has had considerable experience as general manager for sales division of electric refrigerators, domestic and commercial. D-1516.

CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; 37; married. Pennsylvania registration, with broad experience in plant layout, structural design, contract plans and specifications, estimating, and construction. Familiar with water works, sewage disposal, steam power plants, foundations, bridges, viaducts, and general building work. Available at once for responsible charge, or research work. Location Pittsburgh. D-1525.

GRADUATE CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; 8 years varied structural experience; drafting, design, and construction; estimates, inspection, surveys, layouts, and related work. Readily adaptable to new work. Desires reliable connection, preferably with construction company, consultant, contractor, or architect, field or office; also sales-engineering or instructorship. C-2605.

CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; licensed professional engineer, New York State; 25 years experience in design and construction of steam and hydro-electric power plants, transmission lines of all capacities, including 220,000 volts. Industrial plants, electric railways, valuations, estimates, specifications, and purchasing. Desires responsible charge of work. Location New York. B-5423.

GRADUATE CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; 36; licensed New York State; 15 years designing, plans, specifications, and supervision for sanitary and storm sewers, roads, highway and railroad bridges, small steel buildings, parks, and cemeteries; heating, ventilating, and plumbing. Estimator and construction engineer for buildings. Desires connection with contracting company, engineer, or contractor. B-5932.

ENGINEER AND ARCHITECT; M. Am. Soc. C.E.; graduate; 20 years experience in design and construction of industrial and chemical plants, steam power plants, substations, industrial and other housing groups, institutional buildings, sewer and water lines, and all other utilities in connection with factory and housing groups. Organization, field and office forces. Investigations. Reports. B-2835.

STRUCTURAL ENGINEER EXECUTIVE; M. Am. Soc. C.E.; 45; married; over 20 years in structural steel fabricating business in western Pennsylvania and Ohio, directing estimating, designing, and sales, also 3 years as general contractor. Can handle any division of fabricating business or serve as district representative of steel or building construction materials. C-5095.

CIVIL-SANITARY ENGINEER; M. Am. Soc. C.E.; 41; graduate of Massachusetts Institute of Technology; licensed in New Jersey; 18 years experience in surveys, design, construction, operation, appraisal, rates, sanitation, special studies, and reports on water works, sewerage, flood control, and public health problems. Available immediately. A-1869.

IRRIGATION ENGINEER; M. Am. Soc. C.E.; graduate C.E.; 24 years continuous experience in all phases of irrigation work; last 10 years chief engineer and consulting work on projects involving investigation, design, construction, and operation, including design and construction of important storage works; 5 years foreign service; any location. C-5225.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; 28; married; certificate in C.E.; 10 years varied experience in topography, subdivision development, construction, estimating, computing, precise city surveying, mapping, and drafting. Desires permanent position with civil or hydraulic engineering firm. References on request. Location and salary immaterial. Available immediately. D-1573.

JUNIOR

CIVIL ENGINEER GRADUATE; Jun. Am. Soc. C.E.; 26; single; B.S. in C.E., University of Illinois. Passed U.S. Civil Service Examination for both Junior Engineer and Engineering Draftsman. Wants position in any branch of civil engineering, field or office work, anywhere. D-392.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; 28; married; B.S. in C.E. from a leading technical school. Employed for four years by a prominent engineering company as transitman. Drafting, survey, and inspection work on construction projects. References furnished. Desires work in civil engineering field. Location immaterial. D-1541.

JUNIOR CIVIL ENGINEER; Jun. Am. Soc. C.E.; 24; married; B.S. in C.E. from Purdue University; experience in highway construction and drafting; ambitious; willing to work diligently; preference for road, building, or bridge construction in New Jersey; location immaterial if future looks promising. Available immediately. D-1556.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; 26; single; 6 months experience in construction work; 3½ years experience in consulting hydraulic engineer's office. Training in design and drafting. Extensive training in the operation and design of surge tanks. Available immediately. D-1544.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; 26; married; graduate from Georgia School of Technology, 1929; 3 years experience in railroad engineering, steel and concrete design. Traveling experience in North and South America. Speaks Spanish fluently. Willing to travel and will go anywhere. C-6128.

JUNIOR ENGINEER; Jun. Am. Soc. C.E.; 25; B.S. in C.E.; 4 years experience in engineering capacity, in which duties involved tracing, calculating oil tanks, field survey, building inspecting, and design in reinforced concrete and steel, also general map drafting. Desires position with construction company or engineering firm. Available immediately. D-1567.

MISCELLANEOUS

PATENT ATTORNEY; Assoc. M. Am. Soc. C.E.; desires to organize and manage patent department of corporation. C.E. degree. Member New York Bar, U.S. District Bar. Registered Attorney, U.S. Patent Office; 5½ years with old established firm of patent attorneys; before that, 8 years of engineering and management experience. Now in charge of patent work for large corporation. B-1819.

RECENT BOOKS

New books of interest to Civil Engineers, recently donated by the publishers to the Engineering Societies Library, will be found listed here. A comprehensive statement regarding the service which the Library makes available to members is to be found on page 87 of the Year Book for 1932. The statements made regarding the books are taken from the books themselves and this Society is not responsible for them.

ARCHITECTURAL GRAPHIC STANDARDS. By C. G. Ramsey and H. R. Sleeper. New York, John Wiley and Sons, 1932. 233 pp., diagrs., 12 × 9 in., cloth, $6.

Standards and recommended practices in building, with many other data constantly used by architects and designers, are presented in a form unusually convenient for quick reference. The book consists entirely of plates, with a very full index. It covers a broad field, including not only building construction but also the planning of fields for sports and games, swimming pools, gymnasiums, etc.

DIE FAHRWIDERSTÄNDE DES ROLLMATERIALS IM BAUBETRIEB. (Mitteilungen des Forschungsinstituts für Maschinenwesen beim Baubetrieb, Heft 3.) By J. Engel. Berlin, VDI-Verlag, 1932. 35 pp., illus., diagrs., charts, tables, 12 × 8 in., paper, 7.20 rm.

This volume presents the results of a theoretical and practical study of the effect of the rolling resistance of contractors' railway equipment upon the cost of moving earth in building operations. The effects of car construction, bearings, track gage, curve radius, and other items upon rolling resistance are determined, and methods for using the data in estimating and controlling the cost of the work are given.

PRINCIPLES OF REINFORCED CONCRETE CONSTRUCTION. By F. E. Turneaure and E. R. Maurer. 4 ed. New York, John Wiley and Sons, 1932. 461 pp., illus., diagrs., charts tables, 9 × 6 in., cloth, $4.

The aim of this revised textbook is to present systematically the principles of mechanics underlying the design of reinforced concrete, to give the results of available tests which aid in establishing coefficients in working stresses, and to make clear the principles of design by illustrative material from practice. Due consideration has been given to recent developments in methods of calculation and design, formulas and diagrams revised, the material on flat slabs amplified, and a complete detailed analysis of the arch added, together with many other improvements.

SLUMS, LARGE-SCALE HOUSING, AND DECENTRALIZATION. Edited by J. M. Gries and J. Ford. Washington, D.C., President's Conference on Home Building and Home Ownership, 1932. 245 pp., illus., tables, 9 × 6 in., cloth, $1.

This volume gives the conclusions of the Committees on Blighted Areas and Slums, Large-Scale Operations, Business and Housing, and Industrial Decentralization and Housing.

URBAN LAND USES. AMOUNTS OF LAND USED AND NEEDED FOR VARIOUS PURPOSES BY TYPICAL AMERICAN CITIES, an Aid to Scientific Zoning Practice. (Harvard City Planning Studies, Vol. 4.) By H. Bartholomew. Cambridge, Harvard University Press, 1932. 174 pp., maps, tables, charts, 10 × 7 in., cloth, $3.50.

The results of uniform field surveys made in 22 American cities to determine requirements as to the land areas used for various purposes, the ratios of these areas to a given population unit, and analogous statistical information of aid in scientific zoning. These data provide a method for estimating the total area required for each particular urban use for any given future population of between 5,000 and 300,000 inhabitants and will aid in solving the problem of determining the desirable extent of city area and the location of future boundaries.

WASSERBAULICHE MODELLVERSUCHE ZUR KLÄRUNG DER ABFLUSSERSCHEINUNGEN BEIM ABSCHLUSS DER ZUIDERZEE AUSGEFÜHRT IM FLUSSBAULABORATORIUM DER TECHNISCHEN HOCHSCHULE ZU KARLSRUHE. (Rapporten en Mededeelingen Betreffende de Zuiderzeewerken, No. 3.) By T. Rehbock. The Hague, Algemeene Landsdrukkerij, 1931. 282 pp., illus., diagrs., charts, tables, maps, 10 × 7 in., cloth, 17 rm.

From 1922 to 1930 the hydraulic laboratory of the Karlsruhe Technical High School was occupied with model study of the problems connected with the twenty-mile dam which is the keystone of the Zuider Zee reclamation project and the sluiceways in the dam through which the surplus water will be discharged into the sea. In the present volume the director of these investigations presents a general account of the more important problems and of the major conclusions drawn from them.

WICHERT TRUSS. By D. B. Steinman. New York, D. Van Nostrand Company, 1932. 138 pp., diagrs., charts, tables, 9 × 6 in., cloth, $2.75.

This truss, invented and patented by E. M. Wichert, is a truss over two or more spans, in which the members over each intermediate pier form a quadrilateral. Outstanding advantages claimed for it are economy of material, rigidity under traffic, adaptability of outline, ease of analysis, and invariability of stresses. The theory of the truss, the methods of analysis, and its other features are discussed in detail in this book.

CURRENT PERIODICAL LITERATURE

Abstracts of Articles on Civil Engineering Subjects from Magazines in This Country and in Foreign Lands

Selected items from the current Civil Engineering Group of the Engineering Index Service, 29 West 39th Street, New York, N.Y. Every article indexed is on file in The Engineering Societies Library, one of the leading technical libraries of the world. Some 2,000 technical publications from 40 countries in 20 languages are received by the Library and are read, abstracted, and indexed by trained engineers. With the information given in the items which follow, you may obtain the article from your own files, from your local library, or direct from the publisher. Photoprints will be supplied by this library at the cost of reproduction, 25 cents per page, or technical translations of the complete text may be obtained when necessary at cost.

BRIDGES

BASCULE, PHILADELPHIA. Bascule-Arch Span in Philadelphia Toll Bridge. *Eng. News-Rec.*, vol. 109, no. 9, Sept. 1, 1932, pp. 253–254. Description of 260-ft. movable span of Tacony-Palmyra steel bridge; double-leaf rolling bascule span, when closed and under live load, acts as three-hinged arch instead of pair of cantilevers; advantages of arch bascule.

COLD WEATHER CONSTRUCTION. Unemployment Relief Spurs Winter Construction of Highway Bridges. *Construction Methods*, vol. 14, no. 9, Sept. 1932, pp. 14–19. Up-to-date American practice; types of structures; heat losses; heating water and aggregates; mixer heaters; housing; curing concrete.

CONCRETE ARCH, AUSTRALIA. Barrel Arch Without Spandrel Walls Carries Road Over Australian Stream. *Eng. News-Rec.*, vol. 109, no. 10, Sept. 8, 1932, p. 293. Description of highway bridge over Walker's Creek, near Yass, Australia, consisting of arch of 60-ft. span and 19-ft. rise, barrel of arch being extended to slope of embankment on each side, thereby eliminating need for spandrel walls or other method of retaining filling; cost $12,000.

CONCRETE, CANADA. Unusual Concrete Bridges Are Built on Canadian National. *Ry. Age*, vol. 93, no. 11, Sept. 10, 1932, pp. 354–357 and 368–369. Structural features of railroad crossing bridges, built by the Canadian National Railroad, characterized by long and shallow spans; fixed-frame construction and elimination of track ballast; concrete ties used on precast deck slabs; high grade concrete used.

CONSTRUCTION, INDIA. Bridge Construction with Particular Reference to Foundations in Indian Conditions, C. I. Stabler. *Indian Eng.*, vol. 92, no. 6, 7, and 8, Aug. 6, 1932, pp. 116 and 117; Aug. 13, pp. 135 and 136; and Aug. 20, pp. 156 and 157. 8 supp. plates. Riveting; painting; plant and workshops, piling; design of cement concrete mixtures. Before Inst. Engrs., India. (Concluded.)

FRANCE. Reconstruction du Pont de la Ligne de Bordeaux a Sète sur le Tarn, A Moissac, M. Garau. *Annales des Ponts et Chaussées*, vol. 1, no. 3, May–June 1932, pp. 349–407. Design and construction of new steel-truss railroad bridge, 311 m. long, with maximum span of 120 m., at Moissac, on Bordeaux–Sète railroad line, to take place of old bridge destroyed by flood of Mar. 3, 1930.

HIGHWAY. Steel Road Bridges of Small Span, E. Taylor. *Structural Engr.*, vol. 10 (New Series), no. 9, Sept. 1932, pp. 382–388. Progress in steel manufacture; modern trend of bridge manufacture; bearings; flooring; painting corrosion allowance; erection of plate girders; riveting.

INDIA. Bridge Construction with Particular Reference to Foundations in Indian Conditions, C. I. Stabler. *Indian Engr.*, vol. 92, no. 4 and 5, July 23, 1932, pp. 74–75, 1 supp. p.; and July 30, pp. 96–97. Characteristics of good staging; examples from Indian practice; launching of bridge spans; erection of girders. (To be continued.)

LIFT, HACKENSACK RIVER, N.J. Vertical-Lift Bridges Over Hackensack River, N.J. *Engineering*, vol. 134, no. 3476, Aug. 26, 1932, pp. 237–239. Bridges put in commission by Pennsylvania Railroad; operating machinery itself is placed in center of lifting span, as in Welland Canal bridges, but control cabin is on one tower with floor about 25 ft. above rail level.

LIFT, ILLINOIS. Rock Island Lift Bridge Erected on Old Fixed Spans. *Eng. News-Rec.*, vol. 109, no. 8, Aug. 25, 1932, pp. 227–230. Reconstruction of bridge of Rock Island lines over Des Plaines River and Illinois and Michigan Canal, at Joliet, Ill., having a vertical-lift draw-span of 302 ft. flanked by two through-truss fixed spans, 150 ft. and 100 ft.; new bridge is 12 ft. higher and planned for future raising of grade; lift spans and cables; lift-span operation; raising grade under traffic.

MILITARY. Portable Steel Military Bridges, B. H. Bowley, Jr. *Military Engr.*, vol. 24, no. 136, July-Aug. 1932, pp. 344–348. Uses and advantages of timber and of steel bridges; comparative use during World War; French and British steel bridges; R.S.J. type; 60-ft. and 85-ft. types; Inglis and Hopkins bridges; new American steel highway bridge.

STEEL ARCH, CLEVELAND, OHIO. Model Study of Arch Bridge for Statically Indeterminate Stresses, F. L. Plummer. *Eng. News-Rec.*, vol. 109, no. 10, Sept. 8, 1932, pp. 282–283. Report on tests of celluloid model of steel-arch bridge, for Main Avenue in Cleveland, Ohio, consisting of half-through central arch of 270-ft. span and 148-ft. rise, and smaller side-span arches of deck type.

STEEL ARCH, GREAT BRITAIN. Tyne Bridge (1928), C. F. Mountney. *Structural Engr.*, vol. 10 (New Series), no. 9, Sept. 1932, pp. 398–404. Construction of highway bridge consisting of two-pin parabolic arch having a span of 531 ft., and a rise of 170 ft.; main foundations and caissons; caisson trouble; approach spans; Sydney Harbor Bridge and Tyne Bridge compared; painting.

STEEL TRUSS, ARGENTINA. Rio Negro Bridge. *Ry. Gaz.*, vol. 57, no. 8, Aug. 19, 1932, pp. 227–229. New railway and highway bridge on Argentine State Railway system; opening span of rolling-lift type permits effective span of 131 ft. 3 in. for navigation and consists of two main trusses, spaced at same distance as main girders of fixed spans.

STEEL TRUSS, SIAM. Bangkok Bridge. *Engineer*, vol. 154, no. 4000 and 4001, Sept. 9, 1932, pp. 248–249; and Sept. 16, pp. 272–274, and 282, 2 supp. plates. Memorial Bridge commemorates founding of Ratana Kosindra, capitol of Siam; architectural treatment included four large reinforced-concrete pylons, 60 ft. high, behind each of bridge abutments; piers are constructed as hollow filled with mass concrete and were sunk by pneumatic process; erection procedure.

WELDED STEEL. All-Welded Steel Pier, C. Helsby. *Civ. Eng.* (Lond.), vol. 26, no. 312, June 1932, pp. 37–39. Welded steel-frame piers for narrow steel-truss bridge carrying pipe line and footway into River Medway, England; spans are 68 ft. long; piers are founded on 12-in. hollow steel pipe piles; method of making welded pile toes.

BUILDINGS

AIR CONDITIONING. Air Conditioning, C. T. Larson. *Arch. Rec.*, vol. 72, no. 3, Sept. 1932, pp. 204–215. Physical properties of air; measuring atmosphere; need of conditioned air; recommended atmospheres; optimum humidity; health standards; electrical qualities of air; ionization in air conditioning; how conditioned air is produced.

EARTHQUAKE EFFECTS. Calculations for Six-Story Steel Frame Building, C. W. Hamann. *Structural Engr.*, vol. 10 (New Series), no. 9, Sept. 1932, pp. 392–397. Numerical example illustrating application of principles. (Continuation of serial.)

PARTITIONS. Concrete Partition Walls in Chicago Postoffice. *Eng. News-Rec.*, vol. 109, no. 10, Sept. 8, 1932, p. 283. Details of concrete partition walls of new Chicago postoffice, and of plywood forms used in their construction.

THEATERS, ACOUSTICS. Acoustics in Theater Design, P. E. Sabine. *Arch. Forum*, vol. 57, no. 3, Sept. 1932, pp. 261–265. Rules for insuring satisfactory hearing conditions; ceiling design; examples from American practice.

CITY AND REGIONAL PLANNING

ALBERTA, ONT. Progress of Rural and Town Planning in Alberta, H. L. Seymour. *Can. Engr.*, vol. 63, no. 10, Sept. 6, 1932, pp. 11 and 34. There are 52 municipalities interested in program of development, and 20 planning commissions have been appointed.

CONCRETE

AGGREGATES. Crystallized Lime Rock Widely Used as Concrete Aggregate in South. *Pit and Quarry*, vol. 24, no. 10, Aug. 10, 1932, pp. 23–24. Description of quarries of Crystal River Rock Company, Crystal River, Fla.; heaving quality rather than shattering power sought when selecting explosives.

What Water-Cement Ratio Theory Means to Aggregate Producer, F. H. Jackson. *Rock Products*, vol. 35, no. 16, Aug. 13, 1932, p. 35. Discussion of paper previously indexed from issue of Feb. 27, 1932.

DOCK. Well-Planned Bulk Cement Dock. *Contractors and Engrs. Monthly*, vol. 25, no. 2, Aug. 1932, pp. 32–37. Method of cement and aggregate handling; batching and reinforcing by Woodrich Construction Company, New Ulm, Minn., on 11-mile paving job; finishing slab and curb; supplying gasoline.

FORMS. How Plywood Panels for Concrete Forms Are Made from Douglas Fir. *Construction Methods*, vol. 14, no. 9, Sept. 1932, pp. 22–24. Outline of process in series of thirteen photographs.

GRADING. Finding Best Grading for Aggregates, E. Shaw. *Rock Products*, vol. 35, no. 15, July 30, 1932, pp. 13–15. Process worked out by H. P. Cortelyou, Construction Engineer, Los Angeles; study of effect of grading; computation of mix; use of charts; form of daily report of concrete proportions and pour.

MIXING. Mobility of Concrete and Economic Use of Cement, L. N. Jamieson. *Inst. Engrs. Australia—Journal*, vol. 4, no. 7, July 1932, pp. 225–233. Increase in cost of placing incurred by using stony mixes; general equation for mobility of concrete; workability and its relation to economy; mathematical theory of effect of aggregates on voids in cement; experimental verification of theoretical equation of mobility.

New Method of Proportioning Concrete for Road Work, W. W. Zass. *Eng. News-Rec.*, vol. 109, no. 9, Sept. 1, 1932, p. 247. Arkansas method of determining percentage of fine and coarse aggregate in relation to total mineral aggregate, in concrete paving mix, expressed as relation: unity minus solid volume of coarse aggregate equals percentage by solid volume of fine aggregate to be used in mix.

Proportioning Concrete for Durability, R. S. Phillips. *Eng. Journal*, vol. 15, no. 9, Sept. 1932, pp. 423–427. Effect of characteristics of cement in determining compressive strength of concrete; effect of water-cement ratio and curing and results obtained with regard to water tightness; examples of structures showing both satisfactory and unsatisfactory results as regards durability.

SHRINKAGE. Principes d'une Théorie du Retrait du Ciment, M. Freyssinet. *Annales des Ponts et Chaussées*, vol. 1, no. 3 May–June 1932, pp. 408–416. Theoretical discussion of theoretical principles and causes of shrinkage of concrete.

STONE SAND. Gradation of Stone Sand for Concrete, A. T. Goldbeck. *Rock Products*, vol. 35, no. 16, Aug. 13, 1932, pp. 30–31. Abstract of paper previously indexed from *Crushed Stone Journal*, May–June 1932.

SUBAQUEOUS CONSTRUCTION. Novel Telescoping Tremie Tube Is Manually Operated, C. J. Brownell. *Eng. News-Rec.*, vol. 109, no. 9, Sept. 1, 1932, pp. 260–261. Type of tremies developed by California State Division of Highways; lower half, 9-in. sheet-iron pipe slides on upper stationary half, consisting of hopper and section of 8-in. pipe.

CONSTRUCTION INDUSTRY

COSTS. Unit Bid Summary. *West. Construction News and Highways Bldr.*, vol. 7, no. 17, Sept. 10, 1932, pp. 514, 516, 518, 520, and 522. Unit costs bid on river and harbor work, street and road work in Oregon, California, Colorado, and Arizona.

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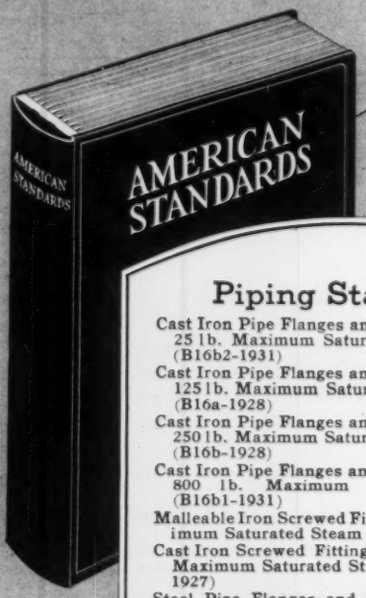

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Continued on page 12

DAMS

ARCH. Pontalto and Madruzza Arch Dams, F. A. Noetzli. *West. Construction News and Highways Bldr.*, vol. 7, no. 15, Aug. 10, 1932, pp. 451–452. Description of two of oldest arch dams on record, built on Fersina Creek in South Tyrol, having variable arch radii at different elevations; dams are 124 ft. and 133 ft. high.

EARTHQUAKE RESISTANCE. Three Dams on San Andreas Fault Have Resisted Earthquakes. *Eng. News-Rec.*, vol. 109, no. 8, Aug. 25, 1932, pp. 218–219. Record of behavior of one concrete masonry and two earth-fill dams, on San Francisco Peninsula, during violent earthquakes; parts of earth dams that straddled fault were moved in 1906 earthquake; 8-ft. shift did not disrupt 85-ft. fill; concrete dam unaffected.

MEXICO. 200-Year-Old Masonry Dams in Use in Mexico, J. Hinds. *Eng. News-Rec.*, vol. 109, no. 9, Sept. 1, 1932, pp. 251–253. Description of three ancient buttressed masonry dams, 36 to 77 ft. in height, built for irrigation development; structures are notable for boldness of profile, disregard for spillway operation, and excellence of hydraulic-lime masonry.

RESERVOIRS, GREAT BRITAIN. Batley Corporation Water Works. Brownhill Reservoir. *Water and Water Eng.*, vol. 34, no. 407, Aug. 20, 1932, pp. 400–406. Description of recently completed Brownhill water supply reservoir and earth-fill, puddle-core dam, 107 ft. high; details of spillway weirs and wasteway 18 ft. wide.

RESERVOIRS, MASSACHUSETTS. Babson Reservoir Built in Six Months, E. B. Myott. *Am. City*, vol. 47, no. 3, Sept. 1932, pp. 49–53. Construction of concrete core earth-fill dam of 35 ft. max. height, forming reservoir with capacity of 200,000,000 gal., for city of Gloucester, Mass.; total cost including appurtenances was $307,000.

ROCK-FILL, NEW MEXICO. Bonito Rock-Fill Dam, New Mexico, W. H. Kirkbride. *West. Construction News and Highways Bldr.*, vol. 7, no. 17, Sept. 10, 1932 pp. 501–504. Design and construction of dumped rock-fill dam, about 100 ft. high; upstream slope protected with concrete slab 8 to 12 in. thick; slope of upstream face is 6 on 7, downstream slope 1 on 1.4; spillway crest 112 ft. long; dam settlement and drift; silt studies; outlet tunnel; outlet pipes and valves.

FLOOD CONTROL

OKLAHOMA. Taking Threat Out of a River *Ry. Age*, vol. 93, no. 9, Aug. 27, 1932, pp. 282–284 and 289. Description of 2,048 lin. ft. of rock-filled timber cribs and 11,327 lin. ft. of heavy-stone revetment, installed by Kansas City Southern at Redland, Okla., and Braden's Bend, to arrest encroachment of Arkansas River on its roadbed; projects cost $310,000.

STREAM EROSION. Erie Solves Severe Erosion Problem in Lateral Streams. *Ry. Age*, vol. 93, no. 10, Sept. 3, 1932, pp. 323–327. Erosion-control works constructed by Erie Railroad in State of New York, between Corning and Hornell; flow reduced to 8 ft. per sec.; seven spillways put in creek; spillway and flume design.

FLOW OF FLUIDS

HYDRAULIC MODELS. Analyzing Hydraulic Models for Effects of Distortion, M. P. O'Brien. *Eng. News-Rec.*, vol. 109, no. 11, Sept. 15, 1932, pp. 313–315. Relation of dimensions in open-channel models; results of study on free-overall model; point of critical depth occurs distance of 18 times end depth back of overfall point, or 11.6 times critical depth; case of non-uniform steady flow.

HYDRO-DYNAMICS. Forces on Flat Plate Placed in Jet of Fluid, S. Tomotika. *Physico-Mathematical Soc. Japan—Proc.*, 3d Ser., vol. 14, no. 6, June 1932, pp. 263–291. Theoretical mathematical discussion of flow of incompressible perfect fluid around flat plate in two-dimensional jet, of finite width; forces are calculated rigorously along lines similar to Olsotti's argument for case of flat plate in unlimited stream; conformal transformations.

FOUNDATIONS

STRESSES. Stress Phenomena Occurring in Pile Driving, E. N. Fox. *Engineering*, vol. 134, no. 3477, Sept. 2, 1932, pp. 263–265. Critical discussion of wave-theory application to pile-driving phenomena; Isaac's theory; alternative theory; derivation of zero-set pile-bearing formula; research is proceeding at Building Research Station in cooperation with Federation of Civil Engineering Contractors, with view to measurement of stresses produced in reinforced-concrete piles on impact.

SUBWAY UNDERPINNING. Jack-Frame Underpinning Offers Advantages, J. L. Washbourne. *Eng. News-Rec.*, vol. 109, no. 10, Sept. 8, 1932, pp. 280–281. Description of system of underpinning for carrying walls and separate columns on footings, used on deep subway construction in New York; system eliminates initial soil disturbance below footings and gives quick transfer of load and rigid tying together of isolated piers; jetting operations; methods of applying grillage beams and piles to wall and column footings.

TESTING. Model Tests of Soil Action Under Footings, G. I. Pokrowski and N. W. Laletin. *Eng. News-Rec.*, vol. 109, no. 11, Sept. 15, 1932, pp. 309–311. Report on tests made at Foundation Laboratory of College of Civil Engineering, Moscow, U.S.S.R.; photographs of soils confined in glass containers showing settlement under piles and footings of various forms; deformation of soils depends largely on dimensions of foundations.

HYDRO-ELECTRIC POWER PLANTS

LINING CANALS. Machine Places Riprap at Beauharnois, J. A. Knight. *Eng. News-Rec.*, vol. 109, no. 10, Sept. 8, 1932, pp. 275–277. Traveler used in construction of power house is rebuilt for use in placing riprap on part of banks of 15-mile intake canal for Beauharnois power plant on St. Lawrence River; description of machine consisting of operating floor about 26 ft. above top of rail and about 40 ft. square; belt conveyor is supported on 100-ft. bridge-type boom suspended from top of mast and pivoted above deck line.

HYDROLOGY, METEOROLOGY AND SEISMOGRAPHY

INDIA. Rainfall, Off-Flow and Storage in Central Provinces, India, G. B. Williams. *Inst. Civ. Engrs.—Selected Eng. Papers*, no. 106, 1931, 25 pp., 2 supp. p. Geography and meteorology of Central Provinces of India; analysis of rainfall run-off records; rainfall at thirteen standard recording stations in Central Provinces for 30 years, 1897–1926; rainfall map of region.

MATERIALS TESTING

STRENGTH OF MATERIALS. Strength of Materials as Affected by Discontinuities and Surface Conditions, F. C. Lea. *Engineering*, vol. 134, no. 3476 and 3477, Aug. 26, 1932, pp. 256–258; and Sept. 2, pp. 280–281. Previously indexed from *Soc. Glass Technology Journal*, June 1932.

MUNICIPAL ENGINEERING

LIMA, OHIO. Lima's Sanitary Improvement Program Completed, R. M. Batch. *Am. City*, vol. 47, no. 3, Sept. 1932, pp. 65–68. Description of river improvements and new activated-sludge sewage treatment plant of Lima, Ohio; population 42,000.

PORTS AND MARITIME STRUCTURES

BUENOS AIRES. Port of Buenos Aires—I, II, and III. *Shipbldg. and Shipg. Rec.*, vol. 40, nos. 5, 6, and 7, Aug. 4, 1932, pp. 102–104; Aug. 11, pp. 134–135; and Aug. 18, pp. 159–160. Port is entirely artificial; plan layout of new works; total length of quay 6,420 m.; facilities; docks and warehouses; quay walls; cranes; grain silos and elevators; railway traction; coal-loading installation.

CANADA. Report by Sir Alexander Gibb. Dominion of Canada National Ports Survey 1931–1932, 1932, 180 pp, 8 supp. maps, $1. National transportation system of Canada; port administration; financial procedure; engineering; proposed form of control and administration; general policy of port development; routing of Canadian grain; tables and graphs.

GREAT BRITAIN. Liverpool Docks Improvement Scheme. *Civ. Eng. (Lond.)*, vol. 26, no. 313, July 1932, pp. 41 and 43. Description of project costing £1,000,000 and involving widening and deepening of dock passages; graving docks reconstructed.

MARINE BORERS. Destruction of Timber by Marine Organisms in Port of Sydney, T. Iredale, R. A. Johnson, and F. A. McNeill. Sydney, published by Sydney Harbor Trust, June 17, 1932, 148 pp., tables, diagrs., figs., and supp. plates. Record of first few years of work inaugurated by Sydney Harbor Trust Commissioners to study marine pile destruction as affecting territory of Port of Sydney, Port Jackson, New South Wales; biological survey; crustacean boring pests; cobra or shipworms; marine animal and plant growths; protective measures and bark protection.

UNITED STATES. Port of Wilmington, Del., and Ports on Delaware River Below Philadelphia. *U.S. Army and U.S. Shipg. Bd.—Port Series*, no. 4, pt. 2, 1932, 119 pp., 7 supp. plates. Revision of older report on such matters as port and harbor conditions, services and charges, fuel and supplies, communications.

ROADS AND STREETS

AFRICA. Road Construction in Tunisia. *Quarry and Roadmaking*, vol. 37, no. 428, Sept. 1932, pp. 376–377. Statistical data; modernization of existing system.

AIRPORT RUNWAYS. Emulsified Asphalt Runways Completed at Dallas Airport, R. B. Koss. *Roads and Streets*, vol. 75, no. 8, Aug. 1932, pp. 341–342. Description of system of all weather runways at Love Field Airport, Dallas, Tex., laid out in eight directions, permitting landings and take-offs under every wind condition; cost $120,000.

ASPHALT. Road Construction in Cold Asphalt, C. E. Tuxen. *Commonwealth Engr.*, vol. 19, no. 12, July 1, 1932, pp. 416–418. Organization and cost of work at Brighton, Vic., in laying asphalt surface 24 ft. wide; roughometer record of new street.

Roughening of Asphalt Surfaces. *Civ. Eng. (Lond.)*, vol. 26, no. 313, July 1932, pp. 44–45 and 53. Methods for finishing paving; roughening surface at time of laying; producing roughened surface on paving already in existence.

AUSTRALIA. Establishment of Direct Road Communication Between Sydney and Newcastle—III, T. H. Upton. *Inst. Engrs. Australia—Journal*, vol. 4, no. 7, July 1932, pp. 234–240. Construction of stretch from Mooney Point to Railway Overbridge, at Gosford, distance of 22 miles, 1,338 ft.

CONCRETE. Batching Plant in Concrete Paving Work, A. P. Anderson. *Pub. Roads*, vol. 13, no. 6, Aug. 1932, pp. 97–103. Functions of batching plant; crane operation, unloading cars to bins; handling bulk cement in hand buggies; yard time constants; effect of yard layout and management on magnitude of time constant; examples of yard layouts.

Cores Reveal Effectiveness of Paving Dummy Joints, H. F. Faulkner. *Eng. News-Rec.*, vol. 109, no. 8, Aug. 25, 1932, p. 232. Specimens from first joints placed in Seattle, eleven years ago, show that device functions as planned.

Reinforcement in Concrete Bases, J. S. Burch. *Surveyor*, vol. 82, no. 2115, Aug. 5, 1932, pp. 115–116. Before Am. Soc. Mun. Engrs., previously indexed from *Can. Engr.*, July 12, 1932.

CURVES. Highway Curve Design, H. Criswell and R. E. Harris. *Roads and Road Construction*, vol. 10, no. 115, July 1, 1932, pp. 196–198. Transition between reverse curves of 5 and 8 deg. (Continuation of serial.)

GRADE SEPARATION. Underpass Carries Parkway Beneath Car-Track Street, J. W. Parker. *Eng. News-Rec.*, vol. 109, no. 11, Sept. 15, 1932, pp. 322–323. Design and construction of new grade separation of Memorial Drive and Massachusetts Avenue in Cambridge, Mass., adjacent to and below level of Charles River Basin; sump pumps required to lift storm water to Charles River Basin.

LOW COST. Low-Cost Bituminous Roads. *Pub. Works*, vol. 63, no. 8, Aug. 1932, pp. 9–11. Requirements for low-cost roads; financial aspects; essentials in low-cost construction; mixed-in-place or road-mix types; construction of macadam aggregate type and of graded aggregate type; surface treatment; plant mixes. Bibliography.

MAINTENANCE AND REPAIR. Paving and Its Maintenance in City of Washington, F. M. Davison. *Am. City*, vol. 47, no. 3, Sept. 1932, pp. 71–75. Concrete pavement maintenance; maintenance of waterbound and bituminous macadam; sheet asphalt maintenance; use of surface heater; surface treatment of macadam and of gravel roads; maintenance of dirt roads by stabilization; dust palliatives; ice removal from streets.

Replacement of Cuts and Openings in Concrete Pavements, F. D. Woodruff. *Roads and Streets*, vol. 75, no. 8, Aug. 1, 1932, pp. 355–358. Before Ass'n Highway Officials of North Atlantic States, previously indexed from *Eng. News-Rec.* Apr. 14, 1932.

MATERIALS, COAL TAR. Modern Developments in Use of Tar for Highway Purposes, G. E. Martin. *Highway Engr. and Contractor*, vol. 41, no. 1, July 1932, pp. 16, 18, 19, and 46. Review of American practice in tar road construction and maintenance work.

SINGLE TRACK. Single Track Concrete Roads in Illinois, E. M. Fleming. *Roads and Streets*, vol. 75, no. 9, Sept. 1932, pp. 393–395. Review of county and township highway construction in Illinois, with special reference to low-cost and single-track concrete road; total of 875 miles of single-track concrete roads has been built.

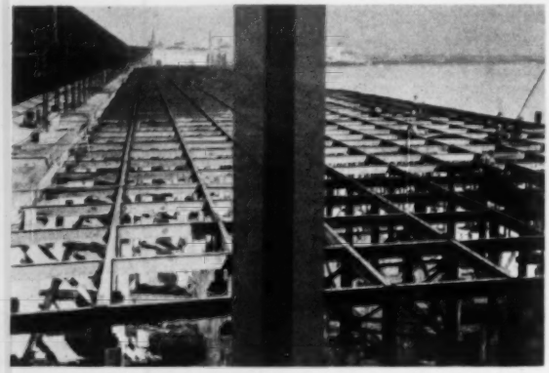
SPECIFICATIONS. Highway Grading Specifications Need Revision, L. E. Wooten. *Roads and Streets*, vol. 75, no. 8, Aug. 1932, pp. 343–345. Borings should be employed to determine character of subsoils.

SEWERAGE AND SEWAGE DISPOSAL

ACTIVATED SLUDGE. Studies of Activated Sludge Process, E. F. Eldridge and G. H. Robinson. *Mich. Eng. Experiment Station—Bull., No.* 46, vol. 7, no. 8, May 1932, 11 pp. Study of activated sludge resulting from treatment of milk waste by mechanical aeration, using Simplex aerator; study is confined to fats, proteins, and carbohydrates. Bibliography.

CHICAGO, ILL. Quarter Century of Progress in Sewage Treatment, L. Pearse. *Sewage Works Journal*, vol. 4, no. 4, July 1932, pp. 647–654. Personal recollections of developments in Sanitary District of Chicago running back nearly thirty years.

EQUIPMENT. Mechanical Equipment in Sewage Treatment Works—II, A. P. Folwell. *Pub. Works*, vol. 63, no. 8, Aug. 1932, pp. 18–21. Fine screens; band screens; wing screens; disposal of coarse and fine screenings; disc screens; incineration.



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GREAT BRITAIN. Unusual Features of Sewage Treatment at Bradford, England. *Pub. Works*, vol. 63, no. 8, Aug. 1932, p. 12. Coal for filter medium; heat for grease removal; advantage of mixing grit and rags with sludge; precipitating wool fat.

ILLINOIS. Overloaded Trickling Filter Plant Relieved by Sedimentation and Chlorination of Excess Flow, A. L. Tholin. *Sewage Works Journal*, vol. 4, no. 4, July 1932, pp. 655–664. Fundamental considerations in design and description of new sewage disposal plant of Downers Grove Sanitary District, 20 miles southwest of Chicago, having population of 11,500 people; Imhoff tanks; sludge beds; chlorine-control units.

Sewerage and Sewage Disposal of Marlow, G. T. Cotterell. *Surveyor*, vol. 82, no. 2115, Aug. 5, 1932, pp. 111–112. Design and construction of sewage disposal system for popular riverside resort having population of 5,200; compressor plant and ejectors; sedimentation tanks; percolating filters; sludge digestion.

MANHOLES. Build Reinforced Brick Masonry Man-Hole at Cost 33 Per Cent Less Than Concrete, C. H. Fork. *Brick and Clay Rec.*, vol. 81, no. 3, Sept. 1932, p. 99. Cost figures prove economy of reinforced brick masonry job built in 19 hours in Dearborn, Mich., in connection with new diversion chamber for city's sewage disposal system; manhole is rectangular, with inside diam. of 3 by 5 ft. and 8 in. thick.

NEW YORK. Sewage Disposal Trends in New York City Region, G. W. Fuller. *Sewage Works Journal*, vol. 4, no. 4, July 1932, pp. 637–646. Summary of accomplishments prior to 1898 and from 1899 to 1919; post-war advances in legislation and administration; proposed Interstate Sanitation Commission.

SEDIMENTATION. New Thoughts in Sedimentation of Sewage, C. A. Smith. *Sewage Works Journal*, vol. 4, no. 4, July 1932, pp. 601–608. Differences between water and sewage sedimentation; classes of sewage settling basins; grit chambers; primary tanks; secondary tanks; factors to be considered in tank design; chemical precipitation; mechanical devices for settling tanks. Bibliography.

Some Points in Sewage Sedimentation, A. S. Lowe. *Civ. Eng.* (*Lond.*), vol. 26, no. 312, June 1932, pp. 21–22 and 46. Treatment of suspended solids; hopper bottomed tank; table of sludge densities and volumes; power consumption; sedimentation graph.

SEPARATE SLUDGE DIGESTION. Destruction of Organic Solids in Sewage by Separate Sludge Digestion, W. R. Copeland. *Sewage Works Journal*, vol. 4, no. 4, July 1932, pp. 672–673. Decomposition of fats and control of pH by ripe sludge. Before New England Sewage Works Ass'n.

SLUDGE. Effect of Coagulants on Sludge Digestion, W. Rudolfs, W. H. Baumgartner, and L. R. Setter. *Sewage Works Journal*, vol. 4, no. 4, July 1932, pp. 628–636. Experimental study of coagulants as auxiliary in coagulation and precipitation of finely divided and colloidal matter in raw sewage or in settling fine materials from settling tanks or sprinkling filters; effect of coagulants on partially seeded material; comparison of daily gas production of different mixtures; effect of bacteria. Bibliography.

Tests on Sludge Beds Show Best Drying Depth, M. M. Cohn. *Eng. News-Rec.*, vol. 109, no. 11, Sept. 15, 1932, pp. 315–316. Studies made in Schenectady indicate that the greatest production of dried sludge per unit area of bed will be obtained with a 10-in. depth when rate of removal is taken into consideration.

SLUDGE DIGESTION. Heat and Energy Relations in Digestion of Sewage Solids—III, G. M. Fair and E. W. Moore. *Sewage Works Journal*, vol. 4, no. 4, July 1932, pp. 589–600. Effect of temperature of incubation upon course of digestion; effect of temperature upon rate of gasification and gas yield; importance of proper seeding. Bibliography.

STRUCTURAL ENGINEERING

BRICK CONSTRUCTION. Investigation of Performance Characteristics of Reinforced Brick Masonry Slabs, J. W. Whittmore and P. S. Dear. *Va. Polytechnic Inst.—Eng. Experiment Station Series—Bull. No. 9*, vol. 25, no. 9, June 1, 1932, 63 pp. Experimental study of effect of physical properties of shale and clay brick on performance characteristics of reinforced brickwork slabs; tests of reinforcing steel, sand, lime and cement, and mortar; bond of mortar to brick; deflection and recovery performance of slabs; comparison of theoretical and experimental stresses and design factors. Bibliography.

COLUMNS. Concrete Columns with Large Bars Offer Advantages, T. Germundsson. *Eng. News-Rec.*, vol. 109, no. 10, Sept. 8, 1932, pp. 277–278. In erection of 13-story building for Rockford Newspapers, Inc., Rockford, Ill., columns with high percentage of 2-in. bars used to save material; floor area and cost over columns designed under codes limiting steel percentage and bar sizes; butt-welded splices; estimated cost per linear foot of columns of different designs.

Assessment of Actual Restraint of Pillars by Practical Construction, G. F. Rodmell. *Structural Engr.*, vol. 10 (New Series), no. 9, Sept. 1932, pp. 366–381. Principles of design of skeletons of buildings, with special reference to provisions of British Code of Practice; effectiveness of tie joists; it seems improbable that there is any practical pillar in multi-storied building, constructed with fire-resisting floors and rigid walls, in which there is single point of contraflexure due to vertical loading; typical connections for assessment of restraint of ends of pillars.

CONCRETE BEAMS. Note sur la Détermination des Efforts Occasionnés dans les Armatures d'une Poutre en Béton Armé par le Retrait du Béton, M. Suquet. *Annales des Ponts et Chaussées*, vol. 1, no. 3, May–June 1932, pp. 337–348. Analysis of stresses in reinforcement of concrete beams due to shrinkage of concrete.

FIXED BEAMS. Contributo alla Trattazione della Trave Incastrata, G. M. Pugno. *Politecnico*, vol. 80, no. 7, July 1932, pp. 374–377. Theoretical mathematical discussion of stresses in single-span fixed beams.

STATICALLY INDETERMINATE STRUCTURES. Continuous Girders on Rigidly - Connected Columns, H. Cross. *Concrete and Constr. Eng.*, vol. 27, no. 7, July 1932, pp. 415–421. Explanatory notes of abstract by G. S. Coleman of article indexed in Engineering Index, 1930, p. 1647 from various sources.

TUNNELS

VEHICULAR, BELGIUM. Scheldt Tunnels, W. L. Lowe-Brown. *Civ. Eng.* (*Lond.*), vol. 26, no. 313, July 1932, pp. 14–17 and 54. Construction of vehicular tunnel, partly lined with cast iron, 28.5 ft. to 31 ft. in diam. and 6,925 ft. long; pedestrian tunnel, 14 ft. in diam. and 1,875 ft. long; driving of steel sheet piling, 60 ft. maximum length; ventilation; compressed air plant; freezing process; footway tunnel shaft; refrigerating plant; cost 295,000,000 francs.

WATER PIPE LINES

NOISE ELIMINATION. Les Conduits d'Eau Considérées comme Source de Bruits dans les Constructions, I. Katel. *Génie Civil*, vol. 101, no. 8, Aug. 20, 1932, pp. 183–184. Study of water service connections as sources of noise and vibrations in buildings; analysis of causes producing noise in water-pipe lines; remedies for prevention of noise in service connections.

WATER TREATMENT

ACTIVATED CARBON. Experience with Activated Carbon, G. R. Spalding. *Am. Water Works Ass'n—Journal*, vol. 24, no. 9, Sept. 1932, pp. 1394–1400. Experience with carbon in pulverized form; newer developments at plant of Hackensack Water Company; controlling characteristics of carbon.

Powdered Activated Carbon Used Without Filtration, A. B. Hess. *Pub. Works*, vol. 63, no. 8, Aug. 1932, p. 13. Experience of Belmont Lake, Pa., with aqua nuchar treatment.

Present Status of Aeration, F. E. Hale. *Am. Water Works Ass'n—Journal*, vol. 24, no. 9, Sept. 1932, pp. 1401–1415 (discussion) 1415. Possible functions of aeration; removal or reduction of undesirable gases; addition of oxygen; removal of odors; aeration as part of other water purification processes; methods of aeration; investigation of Kensico aerator, 1920, Rye Dyke aerator, 1913. Bibliography.

AERATION. Filtration Plants, J. R. Baylis. *Water Works Sewerage*, vol. 79, no. 8, Aug. 1932, pp. 275–281. Part III: Present practice of aeration; purposes of aeration; aerating systems for removal of objectionable odors; aeration for CO_2 removal; iron and manganese removal; description of aerator; aeration for hydrogen sulfide removal; no certain type of aerator can be recommended. Bibliography.

CHLORINATION. Round Table. *Water Works Eng.*, vol. 85, no. 17, Aug. 24, 1932, pp. 1014–1017. Water superintendents' discussion of emergency chlorination operations; algae and bacteria control, chlorination of pipe lines under construction, sterilization of sand filters; use of calcium hypochlorite.

COAGULATION. Floc Formation and Mixing Basin Practice, G. E. Willcomb. *Am. Water Works Ass'n—Journal*, vol. 24, no. 9, Sept. 1932, pp. 1416–1437 (discussion) 1438–1441. Factors affecting composition and formation of floc; modern conditioning practice; effects of conditioning on turbid waters, soft-colored waters, clear sewage contaminated waters; baffle-type agitators, mechanical agitation, spiral flow agitation; compressed air agitation, combined aeration and agitation; hydraulic jump agitation. Bibliography.

FILTRATION. Filter Problems Considered from Angle of Water Softening, C. H. Spaulding. *Water Works Eng.*, vol. 85, no. 18, Sept. 7, 1932, pp. 1082 and 1085. Problems connected with filtering water softened with lime and soda or with lime alone; surface wash as cure for filter washing difficulties in water-softening plant. Before Am. Water Works Ass'n.

FILTRATION PLANTS. Cause and Prevention of Mud-Ball Formation in Rapid Sand Filters, E. S. Hopkins. *Water Works Eng.*, vol. 85, no. 17, Aug. 24, 1932, pp. 1025–1026. Sand size; rate of wash; side-wall cracks; filter washing; practical demonstration of washing; effect of viscosity on washing; sand cleaning. Before Pennsylvania Water Works Operators' Ass'n.

FILTRATION PLANTS, OPERATION. Further Experience with High Rate of Filter Wash, W. C. Lawrence. *Am. Water Works Ass'n—Journal*, vol. 24, no. 9, Sept. 1932, pp. 1358–1361 (discussion) 1361–1363. Recent experience of Baldwin Filtration Plant, Cleveland, Ohio; author recommends filters with larger troughs, larger gutters and sewer valves, adequate strainer systems, and ample heads in wash water tanks.

MANGANESE REMOVAL. Manganese and Its Relation to Filters, P. Boynton and L. V. Carpenter. *Am. Water Works Ass'n—Journal*, vol. 24, no. 9, Sept. 1932, pp. 1341–1348 (discussion) 1348–1351. Appearance of manganese in surface water supplies of bituminous coal districts with development of coal mining and subsequent acid drainage entering streams; manganese content of streams polluted with acid mine drainage; manganese content of some water supplies where sand has become incrusted; effect on operation. Bibliography.

SEDIMENTATION. Sedimentation Basin Research and Design, A. B. Morrill. *Am. Water Works Ass'n—Journal*, vol. 24, no. 9, Sept. 1932, pp. 1442–1458 (discussion) 1458–1463. Review of theoretical and experimental investigation of sedimentation basins; ideal conditions for sedimentation; dispersion tests; sedimentation research; elements of sedimentation basin design; number of basins; dimensions of basins; detention time; sludge storage volume; designing for volumetric efficiency; inlet arrangements; outlet arrangements; covering sedimentation basins.

TASTE AND ODOR REMOVAL. Elimination of Tastes and Odors of Industrial Origin from Public Water Supplies, M. M. Gibbons. *Indus. and Eng. Chem.*, vol. 24, no. 9, Sept. 1932, pp. 977–982. Tastes and odors, which are not removed by preliminary storage, coagulation, and sand filtration, may best be removed by activated carbon; potassium permanganate is beneficial in removing taste and odor from naphtha and fermenting cereal wastes.

Measures Adopted to Rid Boston's Spot Pond Reservoir of Disagreeable Tastes and Odors Due to Algae, S. E. Killam. *Water Works Eng.*, vol. 85, no. 18, Sept. 7, 1932, pp. 1052–1055. Measures taken by Water Division of Boston Metropolitan District to combat outbreak of large growth of Uroglenopsis in storage reservoirs; biological examination of samples of water; ammonia-chlorine treatment; distributing copper sulfate.

WATER ANALYSIS. Fundamental Chemistry of Water Supply: How to Read Water Analysis, J. H. Coste. *Water and Water Eng.*, vol. 34, no. 407, Aug. 20, 1932, pp. 408–412. Composition of earth's crust; solid matter in upland waters and in rivers passing through arable land; solubility of calcite in carbonated water; conversion of standards of concentration. Bibliography.

WATER WORKS ENGINEERING

LAWS AND LEGISLATION. What Courts Have to Say Regarding Obligation to Supply Water, L. T. Parker. *Water Works Eng.*, vol. 85, no. 18, Sept. 7, 1932, pp. 1063–1065. Review of recent court decisions as to when extension of service is justifiable; when water company illegally cuts off water; right of municipality to take private property; legal right of riparian owner.

OPERATION. Round Table. *Water Works Eng.*, vol. 85, no. 18, Sept. 7, 1932, pp. 1066–1068. Practical discussion by water superintendents on licensing water plant operators; plan for training operators.

STANDPIPES. Concrete Reservoir Design, J. R. Baird. *Commonwealth Engr.*, vol. 19, no. 12, July 1, 1932, pp. 411–414. Design and construction of reinforced concrete standpipe for water works of Hamilton, N.Z., having capacity of 2,606,000 gal.; depth of water 85 ft.; diam. of barrel 77 ft.; electric arc welding employed for joining all steel and iron-work; contract price for construction was 21,000 pounds.

TESTING METERS. How Often Should Water Meters Be Tested for Registration? H. F. Blomquist. *Water Works Eng.*, vol. 85, no. 18, Sept. 7, 1932, pp. 1073–1074. Results of six-year tests of eight $^5/_8$-in. meters in Cedar Rapids, Ia.; effect of water on registration; little change in percentage of meterage. Before Am. Water Works Ass'n.

WASTE ELIMINATION. Saving Effected in Unaccounted for Water Through Adoption of Continuous Leakage Survey, A. R. O'Reilly. *Water Works Eng.*, vol. 85, no. 17, Aug. 24, 1932, pp. 1006–1007. Experience in Reading, Pa.; continuous leakage survey followed up by prompt repairs; unaccounted-for water 48 per cent of total; cost of leakage survey and repairs; meter testing, and repair shop.

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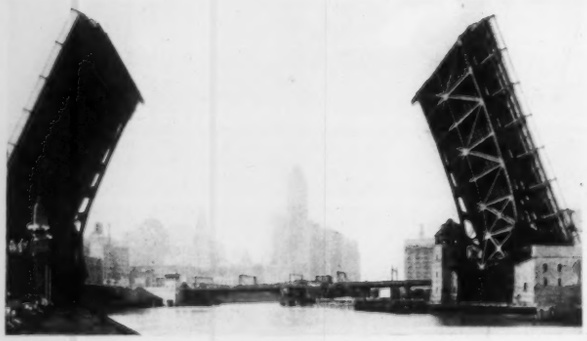

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	PAGE
AMERICAN BITUMULS COMPANY	4
AMERICAN BRIDGE COMPANY	14
AMERICAN STANDARDS ASSOCIATION	10
AMERICAN TELEPHONE AND TELEGRAPH COMPANY	*Second Cover*
CAST IRON PIPE RESEARCH ASSOCIATION, THE	14
EAST JERSEY PIPE COMPANY	12
ELLICOTT MACHINE CORPORATION	*Third Cover*
MCCLINTIC-MARSHALL CORPORATION	10
SPENCER, WHITE & PRENTIS, INC.	*Third Cover*
TEXAS COMPANY, THE	*Back Cover*
VIRGINIA BRIDGE & IRON COMPANY	12
WYCKOFF & SON CO., A.	*Third Cover*

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